

**PROGNOSTIC FACTORS FOR OUTCOME  
IN HIP FRACTURE PATIENTS**

**Volume I**

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## ABBREVIATIONS

ADL	Activities of Daily Living
AMT	Abbreviated Mental Test
AUC	Area Under Curve
BGS	British Geriatrics Society
CRAAG	Clinical Resource and Audit Group
EHFS	Edinburgh Hip Fracture Study
ERSS	Edinburgh Rehabilitation Status Scale
ESDS	Early Supported Discharge Scheme
GDS	Geriatric Depression Scale
GORU	Geriatric Orthopaedic Rehabilitation Unit
HAH	Hospital -At-Home
IADL	Instrumental Activities of Daily Living
ICD	International Classification of Diseases
ICIDH	International Classification of Impairment, Disability and Handicap
IRG	Informant-requiring Group
ISD	Information and Statistics Division
NHS	National Health Service
PADL	Primary Activities of Daily Living
PGCMS	Philadelphia Geriatric Center Morale Scale
PJHQ	Patient Judgements of Hospital Quality
QoL	Quality of Life
RCP	Royal College of Physicians
RIE	Royal Infirmary of Edinburgh
ROC	Receiver Operator Characteristic
SRG	Self-reporting Group
WHO	World Health Organisation

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Dr Edward Dickenson played a key role at the design stage of the study advising on the selection of research instruments to be used. Doctors Mike Robinson and Lance Sloan, Sister Parker and Ms Kath MacPherson enabled experience with the research instruments to be obtained. Dr Colin Currie was also helpful at the design stage of the study advising on questionnaire content and facilitating access to the patients in their rehabilitation centres. The generous support of the medical, nursing, secretarial and clerical staff in all the establishments that were involved in the study is warmly acknowledged. Special thanks are extended to the hip fracture patients and their carers who so willingly agreed to take part in the study.

I would also like to gratefully acknowledge the software assistance given by Mr Paul Rogers and Mr Ji-Xian Wang which was particularly appreciated as it greatly facilitated the completion of the thesis. Thanks must also be conveyed to Ms Jill Brown for secretarial support with the references and to Mr Ian Smith for his initial help with the graphics.

Finally, the financial assistance provided by the Disability and Research Committee of the Scottish Office is also gratefully acknowledged as it enabled the 12 month follow-up interviews to be undertaken.

## **DECLARATION OF OWN WORK**

I hereby declare that I personally undertook the work that was required to produce this thesis. This included the literature review, the study design and production of the questionnaires, all the data collection and entry, the analysis, the interpretation of the results and their subsequent writing up.

A handwritten signature in cursive script that reads "Sue Shepherd".

Sue Shepherd  
11th April 1995



## ABSTRACT

Hip fracture constitutes a major public health problem. Considerable morbidity and mortality ensue and it is expensive to treat. The problem is set to escalate due to a rise in the age-specific incidence rates coupled with the demographic changes of the population. A feasible option to reduce the burden of hip fracture patients appears to be through increasing the efficiency of their rehabilitation by using prognostic indices. Such indices are now being used to guide patient management in conjunction with clinical judgement in other areas of medicine but only a restricted range of work has been undertaken for hip fracture patients. Prognostic indices are also of potential use in clinical audit of patients by permitting case-mix adjustment in different populations, and interest in this is presently gaining momentum in the National Health Service.

It was against this background that the Edinburgh Hip Fracture Study (EHFS) was undertaken. The thesis aims were : to determine the distribution of outcomes over a one year period following a hip fracture; to establish relationships between measures of outcome and the patients' pre-fracture status; and to derive prognostic indices. An unselected consecutive series of osteoporotic hip fracture patients was recruited over a six month period and followed up at one, six and 12 months post-fracture. A broad range of baseline and follow-up data was collected based on the recommendations made in 1992 by the joint working party of the Royal College of Physicians and the British Geriatrics Society for the assessment of the elderly.

270 patients were recruited into the study. They were elderly, physically and mentally frail, and dependent. Normative data on a broad range of baseline characteristics of hip fracture patients and their outcome were obtained. The cumulative mortality was 29%. A general pattern of recovery emerged. At one month post-fracture there was a profound loss of functioning, partial improvement at six months and then a plateauing out over the final six months of follow-up to a point below the baseline level. There was a substantial decline in mobility over the year following the fracture. An unexpected finding was that

12% had a significant degree of femoral shortening. Despite the pattern of increased dependency in the survivors the overall burden at the community level was noted to decline by one year post-fracture due to the frailer individuals dying during the course of follow-up. Prognostic indices were derived for mortality, placement, depression and dependency at one and 12 months post-fracture using multivariate statistical methods. Hip pain and function were also assessed at 12 months post-fracture. The derived indices reflected the importance of age, pre-fracture health, dependency and fracture type on outcome. Depression and social variables were not found to be useful predictors of outcome.

The information obtained in the EHFS may be of use to health service providers, and the derived prognostic indices could help with clinical decision making particularly in the area of rehabilitation. Further work is still required to develop exploit fully the results of the EHFS. Prognostic indices for different dimensions of outcome would benefit from simplification and an overall index for clinical management and audit purposes needs to be derived to indicate the 'severity' of a hip fracture patient. These indices also need to be evaluated in other centres. The EHFS has to date, nonetheless, managed to demonstrate the feasibility of using the indices for triaging and casemix adjustment. It has generated indices which could be used now, although they would require additional data collection from all patients and therefore be a little cumbersome to apply routinely. The EHFS has also identified two areas of unmet need, namely hip pain and femoral shortening; these outcome measures could be used as assessment tools in surgical audit.

# **CHAPTER 1**

## **INTRODUCTION**

### **1.1 INTRODUCTION**

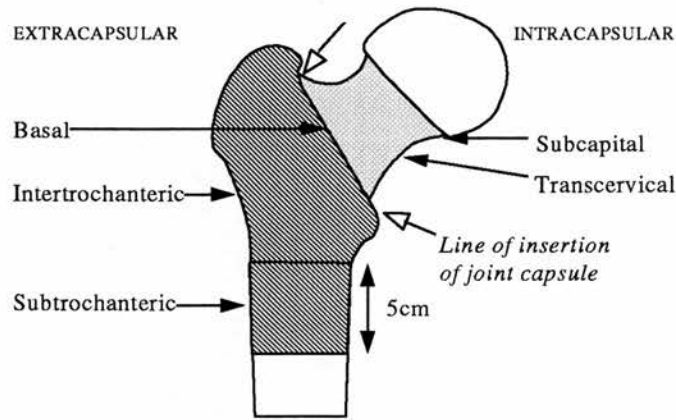
This thesis is based on the results of a study which was performed to assess the outcome of hip fracture patients. It was designed and conducted by the author in Edinburgh between 1991 and 1993 and will subsequently be referred to as the Edinburgh Hip Fracture Study (EHFS). In this chapter information will be presented to put the EHFS into context. It will begin with a review of the epidemiology of hip fractures. The management of hip fracture patients will then be outlined concentrating mainly on the rehabilitation aspects. Some discussion will then be devoted to the importance of clinical audit in relation to hip fractures. To conclude the chapter the specific aims of the EHFS will be presented after justification for why it was needed.

### **1.2 EPIDEMIOLOGY OF HIP FRACTURES**

The purpose of this section is to give an outline of the epidemiology of hip fractures using both published data and Scottish hospital discharge data, provided by the Information and Statistics Division (ISD) of the Common Services Agency of the Scottish Health Service, for Lothian Health Board and Scotland as a whole. It will begin with the definition and classification of hip fractures followed by a discussion on aetiology and the individual risk factors. Secular changes in the incidence of hip fractures and population projections will then be presented. The section will be concluded by a review of hip fracture mortality.

#### **1.2.1 Definition and Classification**

In the literature numerous terms are used for defining and classifying hip fractures which is somewhat confusing. The term 'hip fracture' is the most commonly used term to designate any fracture of the femur involving the femoral head to a level five centimetres below the lesser trochanter. Refer to Figure 1.1. The most correct general term is 'proximal femoral fracture'. The term 'fractured neck of femur' is also used. For ease of presentation the term hip fracture will be used throughout this thesis. Hip fractures can be subdivided according to where they are in relation to the joint capsule as shown in Figure 1.1.



**Figure 1.1** Hip fracture classification

Fractures which occur above the line of insertion of the joint capsule are termed intracapsular fractures, and those below it as extracapsular. This classification is important for prognostic purposes as intracapsular fractures tend to heal less well than the extracapsular fractures. This arises because the blood supply to the head of the femur, via the medial circumflex artery, may be disrupted with an intracapsular fracture, especially if the fracture is significantly displaced.

The classification of hip fractures in the ninth revision of the International Classification of Diseases (ICD) is also based on the site of the fracture and whether the fracture was open or closed. Further detail is presented in Appendix 1 (WHO 1977). A review of the earlier versions of the ICD reveals that classification of hip fractures into intra- and extracapsular fractures is not possible. Useful information however about secular trends in incidence for all closed hip fractures may be obtained as the coding is comparable in revisions 7, 8 and 9.

In this thesis a pragmatic case definition for a hip fracture was used based on the definition used by Greateorex (1988). A hip fracture was defined as being a major fracture which significantly interfered with weight-bearing and was associated with ageing. Isolated greater and lesser trochanteric fractures were not included.

### **1.2.2 Aetiology**

The majority of hip fractures in the elderly have a multi-factorial aetiology and it is not possible to determine the extent to which each component contributes to the fracture and this has implications for the determination of relative risks for individual risk factors. There are three main factors that determine the risk of a hip fracture and these are : bone strength; risk of falling; and the effectiveness of protective neuromuscular responses to a fall (Royal College of Physicians (RCP) 1989). Each of these components will now be elaborated upon in more detail.

#### **1.2.2.1 Bone Strength**

There are three identifiable pathological processes that may weaken bone. The first, and most important of these, is osteoporosis. In this condition there is a reduction in the mineral and organic matrix of the bone so that the mass of bone within a given volume is reduced. Clinically this results in an increased risk of fracture with an inappropriately small degree of trauma. The peak bone density is achieved before the age of 30 years and the rate of bone loss thereafter determines the degree of osteoporosis in old age. The determinants of these factors are not fully understood. The commonest causes of bone loss are ageing, immobility and the menopausal effects and these will be discussed more fully later in this section (Smith 1987).

Bones may also be weakened by a loss of their mineral content and this is termed osteomalacia. Many diseases may cause this condition. In the elderly fracture patient the most common cause has been reported to be a dietary deficiency of vitamin D coupled with a lack of sunlight exposure (Hoikka et al 1982). The contribution of osteomalacia to the overall incidence of hip fracture is less than 5% (Campbell et al 1984, Wilton et al 1987).

Changing the architecture of the bone is the third way of reducing bone strength (Parker and Pryor 1993). This may arise through either distorting the bone structure, as in Paget's disease for example, or replacing it with other tissue as occurs with metastatic deposits.

### **1.2.2.2 Falls**

Falls result from both intrinsic and extrinsic factors. Intrinsic factors include for example, deteriorating eyesight, labile blood pressure, and musculoskeletal pathology. Other factors such as intercurrent illness, medications and alcohol may also increase the susceptibility of the elderly to falls. Environmental factors are also important. In the 65- to 74-year age group hazards outside the home such as irregular pavements are of greatest importance. In the older age groups, or those individuals in poorer health, hazards in their usual home environment, such as loose rugs, constitute the most problem (RCP 1989). The risk of falling increases with advancing age and it has been estimated that 1% of falls in people over the age of 65 years result in hip fractures (RCP 1989).

### **1.2.2.3 Protective Neuromuscular Responses**

As part of the normal ageing process the protective reflexes to prevent serious damage from falls, such as landing on an outstretched hand, begin to fail. This is reflected in the disproportionate rise in the incidence of hip fractures compared to Colles fractures after the age of 75 years. It has been suggested that above 75 it is the loss of the neuromuscular responses, rather than a further reduction in density and bone quality, which is important in determining the risk of fracture (Cooper et al 1987).

## **1.2.3 Risk Factors**

The risk factors for sustaining a hip fracture have been categorised into socio-demographic, medical and lifestyle factors for ease of presentation. The magnitude of the risk associated with each individual risk factor is poorly and not consistently documented in the literature. This is a direct reflection of the difficulty in assessing the independent effect of each risk factor as the cause of most hip fractures in the elderly is multi-factorial.

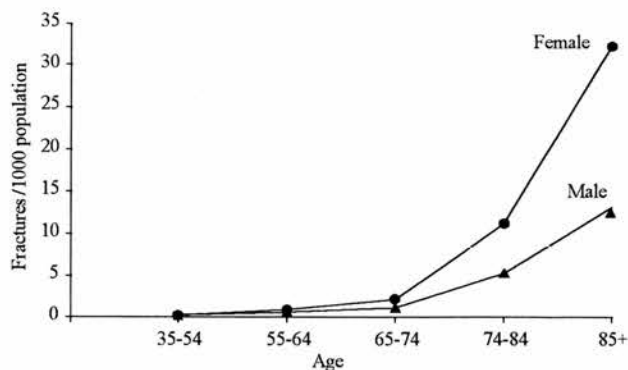
### **1.2.3.1 Socio-demographic**

#### **1.2.3.1.1 Age**

All studies have shown an exponential rise in the incidence of hip fractures with advancing age (Lewis 1981, Boyce and Vessey 1985, Kellie and Brody 1990, Ferrandez et al 1992). See Figure 1.2 for the age-specific incidence rates for men and women in Oxford aged 35

years or more. Figure 1.3 shows the age- and sex-specific incidence rates for Lothian Health Board in greater detail for individuals aged 55 years or more.

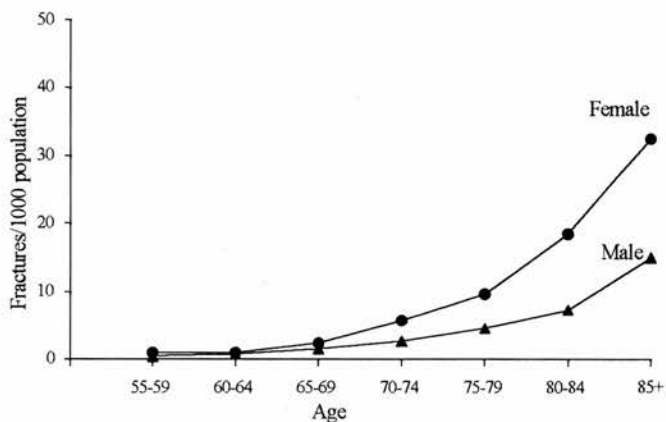
Two types of osteoporosis associated with advancing age, also called involutional osteoporosis, are identifiable and these are termed postmenopausal and senile (Riggs and



**Figure 1.2** Age and sex-specific hip fracture incidence rates in Oxford in 1983 (Boyce and Vessey 1985)

Melton 1986). Postmenopausal osteoporosis arises as a result of diminishing ovarian oestrogen production. Senile osteoporosis is due to a number of factors related to declining metabolism that accompanies ageing. One such factor is the decrease in the active metabolite levels of vitamin D

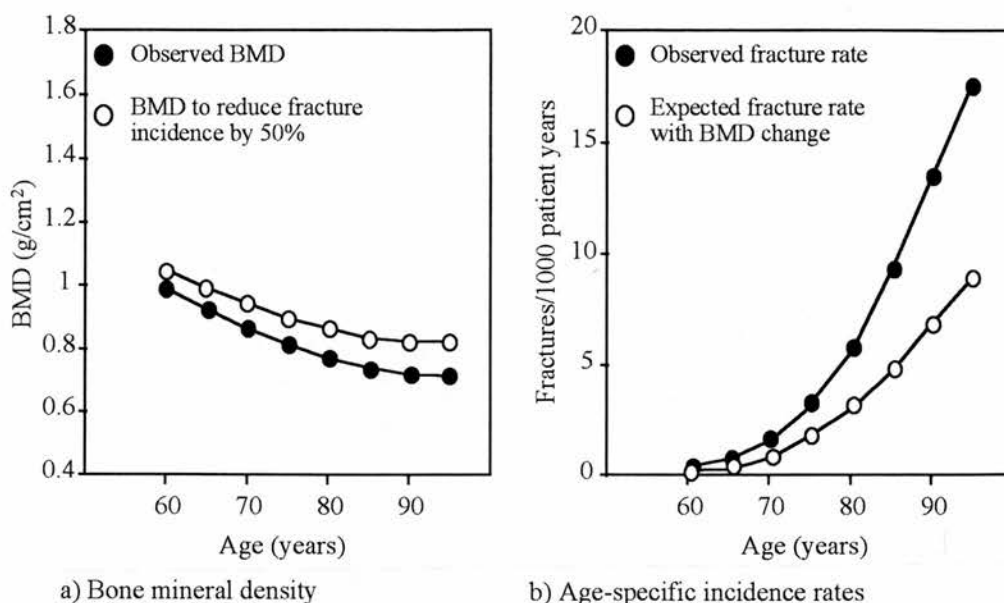
resulting in a reduced calcium absorption from the alimentary tract. Involutional osteoporosis results in a reduced bone mineral density. The relationship between bone mineral density in women and age is given in Figure 1.4 accompanied by a graph depicting age-specific incidence fracture rates. This figure clearly indicates the inverse association between bone mass index and fracture incidence rates.



**Figure 1.3** Age and sex-specific hip fracture incidence rates in Lothian in 1991 (Information and Statistics Division 1993)

The degenerative changes associated with ageing also predispose individuals to fall and to cause the protective neuromuscular mechanisms to fail as outlined in section 1.2.2.3.





**Figure 1.4** Relationship between bone mineral density and hip fracture incidence rates in women (Riggs and Melton 1992)

### 1.2.3.1.2 Sex

The age-specific incidence rates of hip fractures in women is approximately twice that of men after the age of 45 years (Boyce and Vessey 1985, RCP 1989). See Figures 1.2 and 1.3. Due to the larger number of elderly women however a marked female predominance of hip fractures occurs with women accounting for approximately 80% of all the fractures (RCP 1989).

Table 1.1 shows the remaining life time risk of a hip fracture by sex for individuals who have not previously sustained a hip fracture (Martin et al 1991). This table also clearly shows the much higher risk of a hip fracture for women.

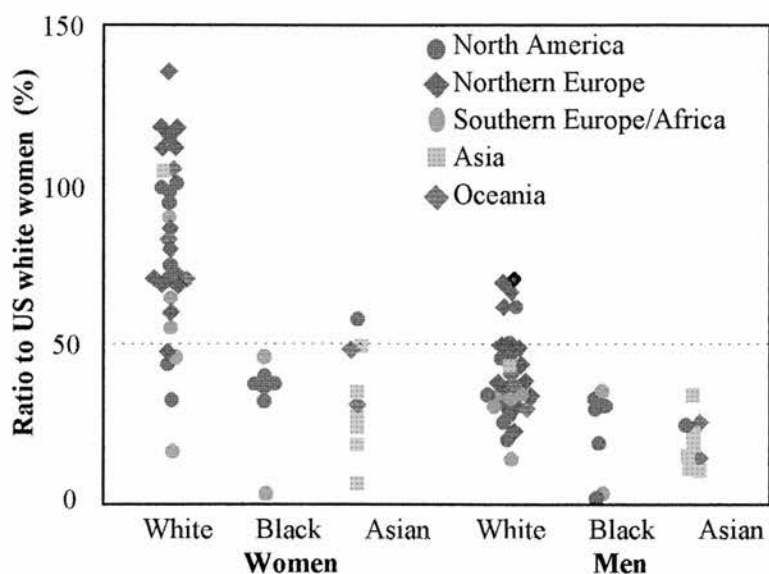
**Table 1.1** Remaining life time risk of hip fracture (Martin et al (1991))

Age (years)	Male (%)	Female (%)
50	2	9
70	4	12
90	8	18

Bone mineral density is lower in women than it is in men at skeletal maturity and this, at least in part, may account for the sex differential in hip fractures (Bonjour et al 1991).



### 1.2.3.1.3 Race



**Figure 1.5** Age-standardised international hip fracture incidence rates by race compared to Caucasian women in USA (Melton (1991))

Racial differences have been reported in the incidence of hip fractures. The literature suggests that Caucasians have higher age-specific incidence rates than Negroid or Mongoloid people (Levine et al 1970, Wong 1984, Silverman and Madison 1988, Jacobsen et al 1990, Kellie and Brody

1990, Ho et al 1993). Refer to Figure 1.5 for a graphical summary of age-specific incidence rates for different racial groups in the various subcontinents. For Caucasians the remaining life time risk for a hip fracture from the age of 50 years onwards is 9% compared to 6% for Negroid women (Cummings et al 1985, Martin et al 1991).

### 1.2.3.1.4 Geography

#### 1.2.3.1.4.1 Rural/Urban

Lower incidence rates have been noted in rural populations than in urban ones (Mannius et al 1987, Sernbo et al 1988, Jarnlo et al 1989, Ray et al 1990). An exception to this was the Scottish study by Swanson and Murdoch in 1983. These researchers found a higher incidence in the environs of Dundee than in the city of Dundee. The reason for this inconsistent finding is not clear.

It has been postulated that differences in activity levels between rural and urban populations may be a contributory factor. Activity as a risk factor will be discussed more fully in section 1.2.3.3.1.

### 1.2.3.1.4.2 *National/International*

Internationally the highest age-standardised rates occur in westernised societies. See Table 1.2. The highest rates for both men and women can be seen to occur in the United States with rates of 50.5 and 101.6 per 100,000 per year respectively (Cummings et al 1985).

Within Europe the incidence rates of hip fractures have been noted to vary widely, with the highest incidence occurring in Northern Europe and the lowest in the Mediterranean area (Kanis 1993). A seven

**Table 1.2** International age-standardised hip fracture incidence rates by sex (Cummings et al (1985))

Region	Women	Men	Female/male ratio
United States (Rochester MN)	101.6	50.5	2.01
New Zealand	96.8	35.2	1.79
Sweden	87.2	38.2	2.75
Jerusalem	69.9	42.8	1.63
United Kingdom	63.1	29.3	2.15
Holland	51.1	28.5	1.80
Finland	49.9	27.4	1.78
Yugoslavia*	39.2	37.9	1.03
Hong Kong	31.3	27.2	1.15
Yugoslavia**	17.3	18.2	0.95
Singapore	15.3	26.5	0.58

\* Low calcium diet

\*\* High calcium diet

and 11 fold difference in incidence rates for men and women respectively have been reported (Johnell et al 1992).

Differences in the quality of the data and the access to medical care must be borne in mind when interpreting international differences in incidence rates. Contributory factors include differences in the definition of a hip fracture, differences in case ascertainment and the use of different age-groups in studies. Nonetheless there does appear to be quite a wide variation in the incidence of hip fracture between countries. It has been suggested that physical activity levels may be partly responsible for the differences (Lewinnek et al 1980, Mannius et al 1987). Other lifestyle and environmental factors may also have a role.

On the whole there is a paucity of information on regional variation of hip fractures within countries. In England and Wales a two fold variation across the 15 health regions has been observed (RCP 1989). In the United States higher rates have been noted in the south than in the northeast (Bacon et al 1989, Jacobsen et al 1990, Stroup et al 1990). No

presently recognised factor, or factors, adequately explain this observed geographical variation.

### **1.2.3.2 Medical Factors**

#### **1.2.3.2.1 Lack of Oestrogen**

Oestrogens prevent bone loss. Observational studies have shown that women who have had an artificial menopause and are not given replacement oestrogen therapy have an increased risk of hip fracture. Post-menopausal oestrogen therapy has also been shown to be protective against hip fractures with case-control studies showing a relative risk of 0.3 for women who have taken hormone replacement therapy (Hutchinson et al 1979, Weiss et al 1980, Kiel et al 1987). Randomised controlled trials have similarly shown the protective effect of oestrogens against bone loss (Christiansen et al 1980).

#### **1.2.3.2.2 Other Medical Conditions**

Impaired vision has been shown to be associated with an increased risk of hip fracture presumably because it predisposes to falls (Felson et al 1989, Grisso et al 1991).

A higher prevalence of rheumatoid arthritis and Parkinson's disease has been noted in hip fracture patients than in the general population. The prevalence for the former being documented between 2% and 7% and for the latter around 3% (Stromqvist 1984, Holmberg and Thorngren 1987). A past history of a gastrectomy has also been reported as being a risk factor for a hip fracture as well as diabetes mellitus (Zetterberg et al 1984).

Medical conditions which result in disuse osteopenia of the femur have been well established as predisposing factors for a hip fracture. Cerebrovascular accidents and poliomyelitis are examples (Brocklehurst et al 1978, Mulley and Espley 1979, Muckle and Miscony 1980, Grisso et al 1991).

#### **1.2.3.2.3 Medications**

Lewis in 1981 suggested that the increasing use of prescribed medications by the elderly may be one of the contributing factors to the rising incidence of hip fractures. Bone

strength could be directly affected or side-effects such as postural instability could cause problems. Corticosteroids, antihypertensives, nervous system depressants and thyroxine, amongst others, have been described to be associated with an increased risk of hip fracture (Muckle 1977, Boyce and Vessey 1988, Taggart 1988, Tinetti et al 1988).

#### **1.2.3.2.4      Previous Hip Fracture**

The percentage of patients who have sustained a previous hip fracture has been reported in the literature as ranging from 6% up to 12% (Johnell and Sernbo 1986, Schroder et al 1993).

#### **1.2.3.3          Lifestyle**

##### **1.2.3.3.1      Activity**

Case-control studies have indicated that patients who were less active as a young adult or in their middle age are at increased risk of a hip fracture (Astrom et al 1987, Boyce and Vessey 1988, Cooper et al 1990, Cumming and Klineberg 1994).

Bedridden patients lose about 1% of their cancellous bone each week. An elderly patient who is bedbound may lose more bone in one month than they would have done during one year of normal activity. Even if the patient regains their previous level of mobility little of this bone loss can be reversed. Controlled trials in post-menopausal women have shown that regular episodes of moderate exercise decrease the rate of bone loss (RCP 1989).

##### **1.2.3.3.2      Smoking**

Smoking has been looked at as a risk factor for hip fractures in a number of studies and the majority have found smoking to be a predisposing factor (Williams et al 1982, Lau et al 1988, Vecchia et al 1991, Cumming and Klineberg 1994).

Tobacco has an inhibitory effect on oestrogen metabolism (Barrett-Connor 1990). Smokers also have a lower body weight predisposing them to fracture. The magnitude of the direct effect of tobacco on lowering bone density is uncertain (Barbieri et al 1986, Michnovicz et al 1986).

#### **1.2.3.3.3**      Alcohol

Numerous studies have documented the association between alcohol intake and hip fractures (Johnell and Sernbo 1986, Lau et al 1988, Felson et al 1988, Hemenway et al 1988, Cumming and Klineberg 1994).

In heavy alcohol drinkers bone mineral density is lower and bone loss is more rapid. Alcohol may have a direct toxic effect or it may have an indirect effect due to poor nutrition, reduced body weight, cigarette smoking or reduced physical activity. It also predisposes to falls (RCP 1989).

#### **1.2.3.3.4**      Nutrition

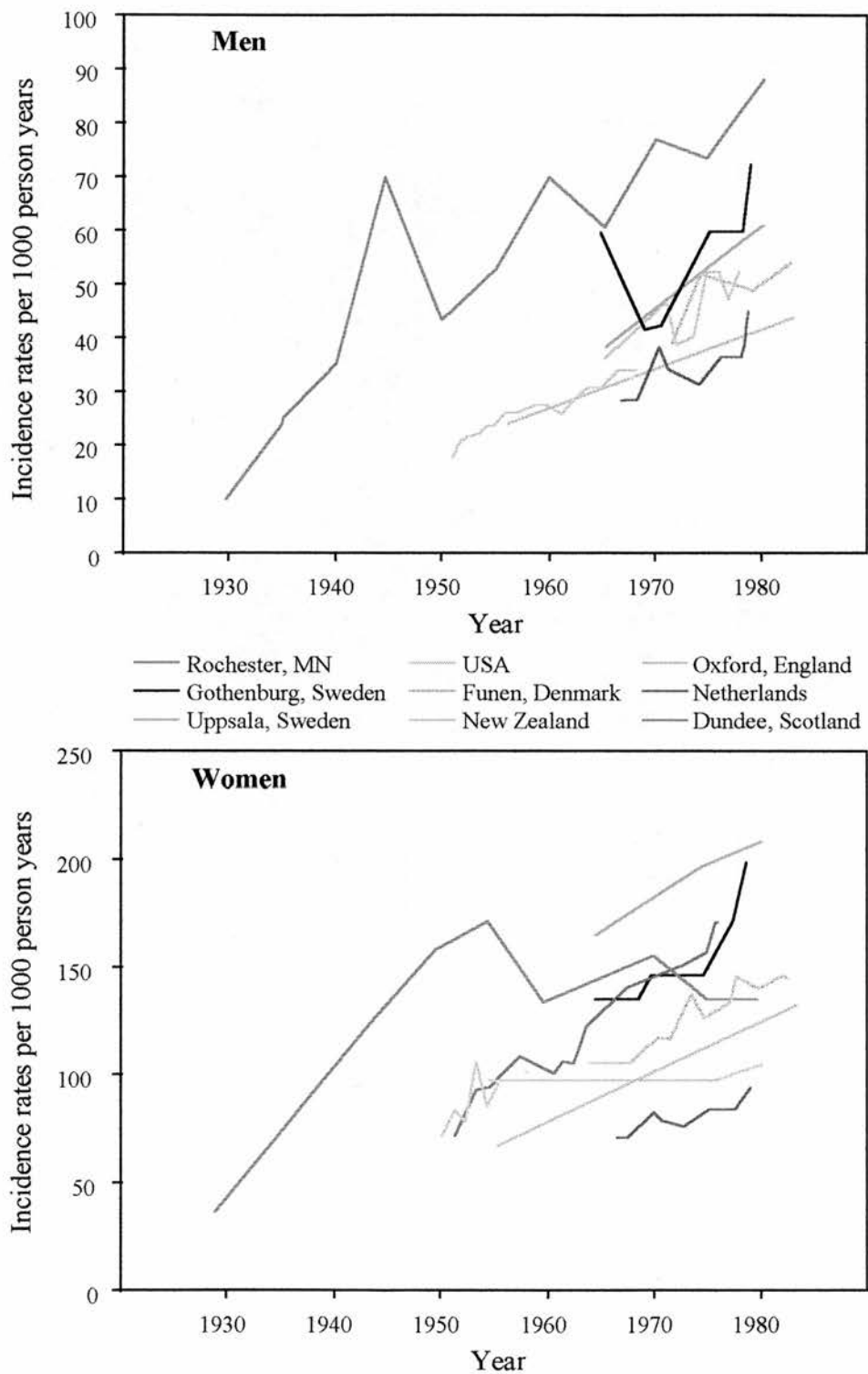
A leaner body build is a risk factor for a hip fracture (Williams et al 1982, Stevens and Mulrow 1989, Pruzansky et al 1989, Vecchia et al 1991, Cumming and Klineberg 1994).

Adipose tissue may increase the amount of biologically available oestrogen and this may explain in part why thinner people have a greater risk of fracture. The padding effect of adipose tissue may also be protective. Additionally it has been suggested that the larger body-weight of more obese patients may help maintain bone strength. Furthermore, it may be that adipose tissue protects against the development of hypothermia which may impair co-ordination and increase the tendency to fall (Bastow et al 1983).

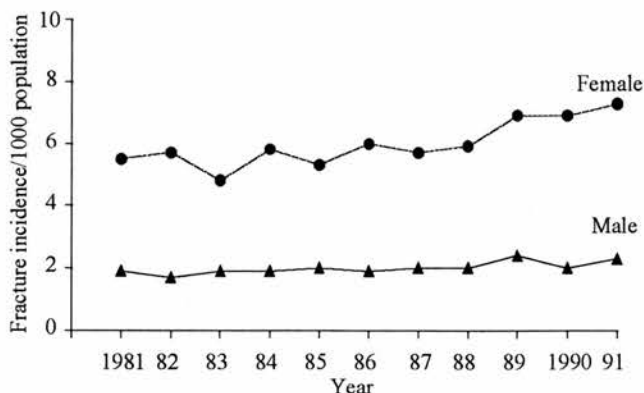
Dietary calcium may have a role to play in the reducing the risk of hip fracture. Observational evidence suggests that dietary calcium in childhood and adolescence may influence peak bone density. Calcium supplementation may also provide protection against osteoporosis in post-menopausal women by decreasing the rate of bone loss. The magnitude of the effect on bone density appears to be half that of oestrogen supplementation (Dawson-Hughes 1991, Elders et al 1991). The overall magnitude of effect on the risk of fracture with calcium supplementation is unknown (Riis et al 1987).

1.2.4 Secular Trends in Incidence

International secular changes in incidence rates over the last 50 years are illustrated in Figure 1.6. Figure 1.7 shows the sex-specific incidence rates of hip fractures for Lothian



**Figure 1.6** Secular changes in international age-standardised hip fracture incidence rates by sex (Melton et al (1987))

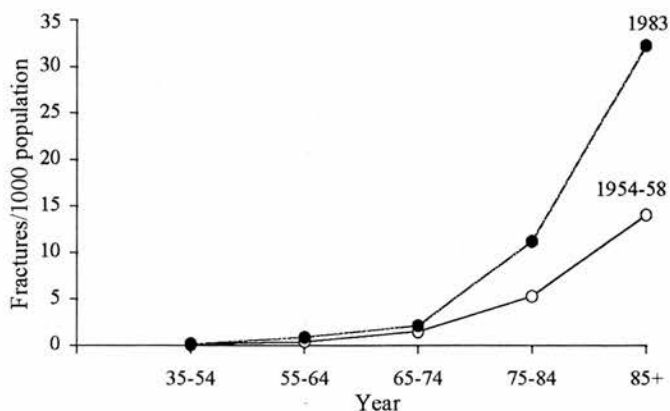


**Figure 1.7** Secular changes in hip fracture incidence rates for Lothian by sex (Information and Statistics Division 1993)

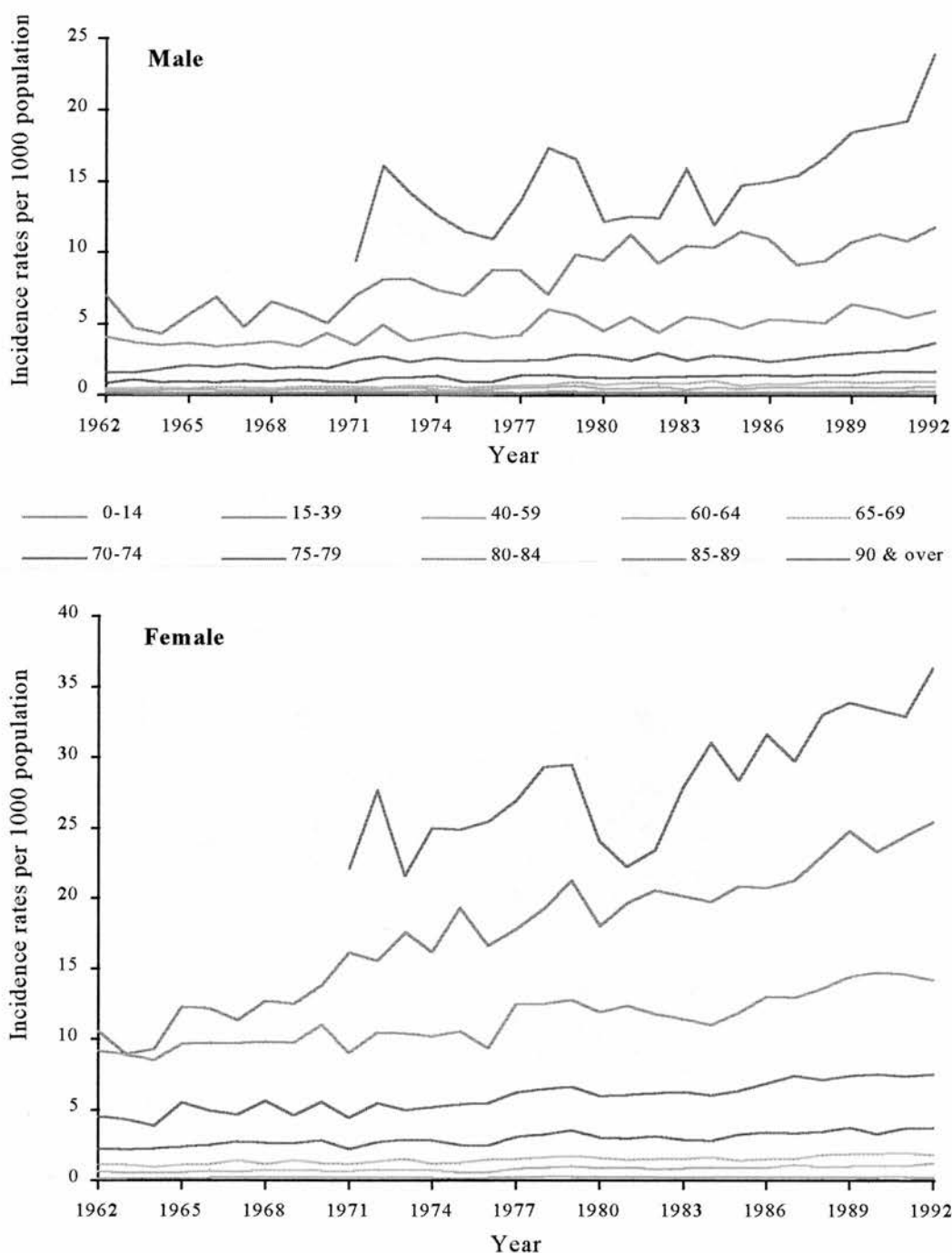
Health Board over the period 1981 to 1991 for people over the age of 55 years. Figures 1.6 and 1.7 both show that the rise in incidence rates has been greater for women than men.

The average age of patients has progressively increased over the last half century and older patients have higher age-specific incidence rates than younger patients as shown in Figures 1.2 and 1.3. In 1955 Stewart reported an average age of 73 years for English hip fracture patients but by the early 1990's this had risen to 79 years (Parker and Pryor 1993).

A rise in age-specific rates has been documented by Boyce and Vessey (1985) and their data is shown in Figure 1.8 for women. These researchers found that the age-specific incidence rates in Oxford doubled between 1954-58 and 1983. Figure 1.9 reveals the increase in rates by sex for Scotland as a whole over the last 30 years. This figure clearly show that the increase in age-specific incidence rates has been most marked in the older age groups. Most of the recent work has suggested that the age-specific incidence rates may now be levelling (Melton et al 1982, Lizaur-Utrilla et al 1987, Melton et al 1987, Spector et al 1990, Luthje 1991).



**Figure 1.8** Secular changes in hip fracture incidence rates for women in Oxford (Boyce and Vessey 1985)



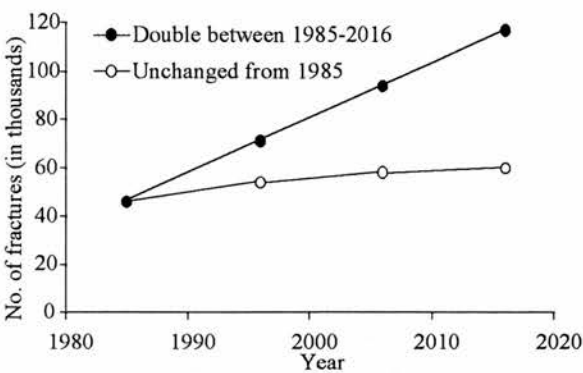
**Figure 1.9** Secular changes in age-and sex-specific incidence rates in Scotland (ISD (1994))

### 1.2.5 Population Projections

If the age-specific incidence rates for hip fractures remained unaltered over the next few decades the demographic transition of the population would in itself produce a substantial increase in the number of hip fractures that would be sustained. It has been calculated in England and Wales if the 1985 age-specific incidence rates were to remain constant



over the following 30 years then the ageing of the population would result in a 33% increase in the annual number of hip fractures (RCP 1989). This would result in approximately 60,000 new cases per year by the year 2016. However if the age and sex-specific incidence rates were to continue to rise, as they have done

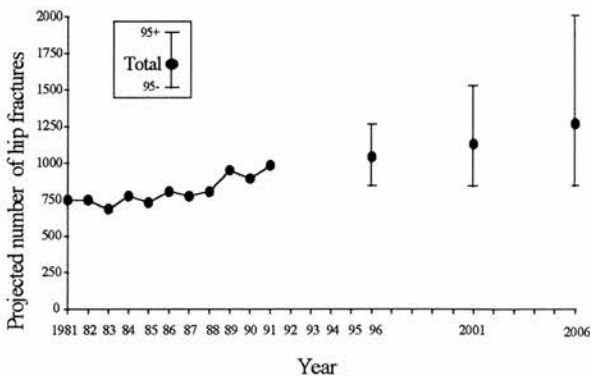


**Figure 1.10** Projected number of hip fractures by age- and sex-specific incidence rates for England and Wales (RCP 1989)

over the last 30 years, there would be a doubling in incidence by the year 2016. This would mean approximately 117,000 new cases per year by that date which would reflect an increase of 254%. See Figure 1.10. Similar predictions have been made in other westernised countries (Schneider and Guralnik 1990, Martin et al 1991, Nilsson et al 1991).

Projections for Lothian Health Board made by Muir in 1994 are shown in Figure 1.11 from data supplied by ISD of the Scottish Health Service. It can be seen that by the year 2001 the number of hip fractures are expected to increase by around 20% from the 1991 level which represents an additional 200 fractures per year.

In 1990 56% of the world's hip fractures were sustained by people living in developed countries. However it has been estimated that by the year 2050, 71% of the 6.26 million

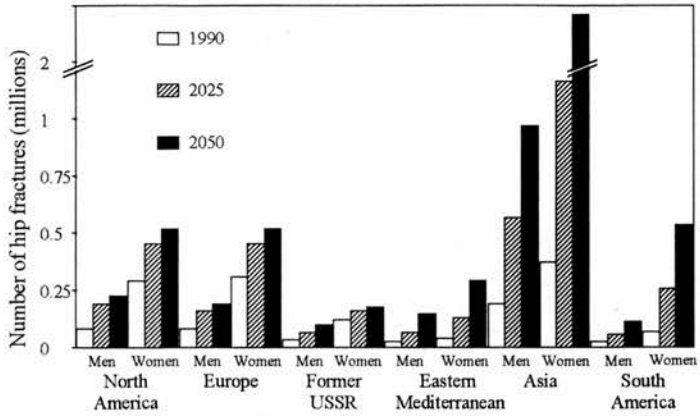


**Figure 1.11** Projected number of hip fractures in Lothian using 1991 age- and sex-specific incidence rates (Muir 1994)

hip fractures that will occur worldwide will be sustained by people living in Africa, Asia, South America and the eastern Mediterranean region. Refer to Figure 1.12. This is a direct reflection of the demographic changes that are anticipated (Cooper et al 1992).

1.2.6 Mortality

The reported mortality rates for patients sustaining a fractured neck of femur vary widely in the literature and there are numerous factors which must be taken into account when interpreting the results of mortality studies. The year the study was performed has an



**Figure 1.12** Projected number of international hip fractures using 1990 age- and sex -specific incidence rates (Cooper et al 1992)

important bearing as there has been much improvement in hip fracture patient management, especially over the last thirty years, with the advances in surgical and anaesthetic techniques that have occurred. Counterbalancing this is the fact that the average age of hip fracture patients has been rising, as outlined in section 1.2.4 and older patients have a higher probability of dying (Registrar General Scotland 1994). Selection criteria of the patients themselves is also important as some studies have restricted themselves to particular sub-groups which directly affect mortality. For example, the inclusion only of patients resident in the community results in a healthier population being selected. The age of the patients also has an important bearing on mortality as well as the mechanism by which the injury occurred. A young person who has sustained a hip fracture as a result of a road traffic accident, for example, has on the whole a better prognosis than an elderly person who fractures a hip as a result of a fall. As with any epidemiological study other factors, such as sample size, also need to be considered when reviewing the results of mortality from individual studies.

Despite the methodological difficulties in ensuring comparable study populations, an increased mortality rate is reported for patients sustaining a hip fracture compared to an age- and sex-standardised population. The excess mortality has been noted to be greatest in the first few months following the hip fracture and returns to that of the general population one to two years post fracture (Gordon 1971, Jensen and Tondevold 1979,

Dahl 1980, Kenzora et al 1984, White et al 1987, Magaziner et al 1989, Parker and Anand 1991). Refer to section 4.7.2 for further detail. Studies performed in the last ten years report in-hospital death rates of around 4%, rising to 8-19% at three months, 12-34% at six months and 14-43% at twelve months (White et al 1987, Elmerson et al 1988, Petitti and Sidney 1989, Foubister and Hughes 1989, Magaziner et al 1989, Kuokkanen and Korkala 1992, Mullen and Mullen 1992, de Palma et al 1992).

The baseline factors which influence mortality will be discussed in sections 5.2.2.1 and 6.2.2.1.

### **1.3 HIP FRACTURE MANAGEMENT**

There are three identifiable components to the management of hip fracture patients. The first of these is a comprehensive patient assessment followed by the definitive surgical treatment of the hip fracture which is then followed by the rehabilitation phase (Parker and Pryor 1993). Each of these components will now be discussed with the main emphasis being on the rehabilitation component.

#### **1.3.1 Patient Assessment**

A comprehensive assessment of hip fracture patients is required as the majority of patients are elderly and frail with multi-system pathology. The physical and mental state of the patient needs to be documented as well as their pre-fracture mobility and dependency levels. A social assessment should also be performed covering aspects such as with whom the patient was living prior to their fracture, the degree of social support available and the type of accommodation they were living in. A joint working party from the RCP and the British Geriatrics Society (BGS) in 1992 recommended that standardised assessment scales should be employed to assist with the full assessment of the elderly patient. These assessment instruments will be considered in more detail in the following chapter.

#### **1.3.2 Surgery**

After the initial assessment of the hip fracture patient, surgery should follow as soon as possible. The surgical techniques used are outwith the scope of this thesis but the reader is

referred to the comprehensive review by Parker and Pryor (1993) in their authoritative text. To summarise, an intracapsular fracture may be either reduced and internally fixed or a joint replacement may be performed depending upon whether the fracture is displaced or undisplaced. An extracapsular fracture is managed with either a dynamic hip screw or an Ender's nail if the fracture is only in two parts with minimal displacement and the bone quality is good. Conservative treatment is limited to obviously moribund patients.

### **1.3.3 Rehabilitation**

The aim of rehabilitating elderly hip fracture patients is to return them to their pre-fracture level of independence and mobility as soon as possible without jeopardising the successful treatment of their hip fracture. Medical, functional and social factors have to be taken into account and consequently the rehabilitation of hip fracture patients can represent a substantial challenge (Parker and Pryor 1993).

In this section the reasons why hip fracture patients require specific rehabilitation measures will firstly be outlined. This will be followed by a consideration of the various types of rehabilitation programmes that are currently available.

#### **1.3.3.1 Rationale for Specific Rehabilitation Measures for Hip Fracture Patients**

The reasons for providing specific measures for hip fracture patients may be viewed in terms of the individual patient and also at the societal level and will be discussed under these two headings.

##### **1.3.3.1.1 Individual Level**

Sustaining a hip fracture is a major medical event for a person of any age. The typical hip fracture patient is frail and elderly and as a result of this, their recovery is often lengthy and difficult. Recovery may take many months during which time the patient can be quite dependent. Measures which facilitate the return of independence are therefore of paramount importance. To achieve this the involvement of a broad range of medical and paramedical personnel both in the hospital and community settings is required. If this is

not instigated the patient may remain in hospital for an extended period of time with the attendant risk of increasing institutionalisation and further loss of independence (Anonymous 1982, Jensen and Bagger 1982). This further diminishes the likelihood of the patient returning to their pre-fracture place of residence.

#### **1.3.3.1.2      Population Level**

The number of hip fractures presently occurring is sufficient to make it a significant public health problem. Moreover, as outlined in the epidemiology section this problem is set to escalate further. Given that only finite health care resources are available, and that hip fractures already account for a large proportion of the orthopaedic allocation, it is necessary to find ways to improve the management of these patients in order to contain costs. This is particularly salient in the light of the fact that prevention at present appears to offer limited potential in reducing the number of fractures and the scope for improvement in surgical techniques is limited.

#### **1.3.3.2          Rehabilitation Programmes**

Four main types of rehabilitation programmes are identifiable namely traditional care, ortho-geriatric liaison, geriatric orthopaedic rehabilitation units, and the early supported discharge schemes (Parker and Pryor 1993). Of these, the last two offer the greatest potential to increase the efficiency of hip fracture management and as a consequence will be discussed in greater detail.

##### **1.3.3.2.1      Traditional Care**

In this type of programme the patient remains on the orthopaedic ward after the definitive management of their hip fracture and is managed by the orthopaedic team. Comprehensive medical, functional and social assessments may not be undertaken. The patients stay on the ward until either deemed fit to return to their original place of domicile or until more dependent forms of care are found where this is necessary. In this type of care the fitter patients are usually discharged without much delay. The frailer patients however may linger with the inherent risk of becoming more dependent and being less likely to return to their pre-fracture state (Parker and Pryor 1993). One study has

suggested that 28% of the bed days occupied by hip fracture patients were due to the patients waiting for discharge as their medical and surgical care was complete (Robbins and Donaldson 1984).

#### **1.3.3.2.2      Ortho-geriatric Liaison**

In this type of care a multi-disciplinary team is involved with the care of the hip fracture patients on the acute orthopaedic wards. This may range from selected patients being assessed by a geriatrician and transferred to a care of the elderly ward through to formal joint ward rounds involving a multi-disciplinary team. A shorter length of hospital stay and a higher discharge rate back to the community has been reported for this type of management (Blacklock and Woodhouse 1988).

#### **1.3.3.2.3      Geriatric Orthopaedic Rehabilitation Units**

The geriatric orthopaedic rehabilitation units (GORUs) are specially established rehabilitation units for elderly fracture patients, the majority of whom have sustained hip fractures. In these units the patients undergo an intensive rehabilitation programme. The opportunity also exists for a thorough medical examination of the patients to be performed and it has been suggested that this is one of the functions of the GORUs (Irvine and Devas 1963). This is often a useful undertaking as a medical cause for the fall leading to the fracture may be uncovered or some other occult pathology may be diagnosed. These units also allow for effective discharge planning of the patient whether it be back to their pre-fracture place of residence or into more dependent forms of care.

Rigorous evidence for the efficacy of GORUs does not exist. Only two randomised controlled trials have been performed to date and their results have been equivocal. Gilchrist et al (1988) reported no significant reduction in mortality, length of stay or place of discharge in patients managed in a GORU compared to those patients treated traditionally. It was noted that more patients in the GORU had new medical conditions diagnosed and treated. Physical dependency measures were not reported in this study. The second randomised controlled trial by Reid and Kennie (1989) found a significantly lower mortality and loss of independence in their GORU managed patients. However the



treatment and control groups were not directly comparable as the treatment group were significantly younger and had a better mental state. These factors could have confounded the observed results (Smith 1988). More general evidence for the usefulness of a geriatric evaluation unit in improving the outcome of elderly patients comes from an American randomised controlled study (Rubenstein et al 1984, Rubenstein et al 1988). Improved functional status and morale of general medical patients managed in the unit were observed as well as a reduction in mortality for selected groups of patients. Fewer acute hospital bed days were occupied and there were not as many acute hospital readmissions.

Several non-randomised studies provide evidence that GORUs are beneficial. A reduction in hospital stay and a higher proportion of patients returning home has been noted by Boyd et al (1982), Murphy et al (1987), Whitaker and Currie (1988) and Hempsall et al (1990). Observational evidence for the benefit of rehabilitation has been documented by Fitzgerald et al (1988). These researchers noted that hip fracture patients had a poorer outcome in terms of reduced mobility and a higher discharge rate to nursing homes after the prospective payment system was introduced in America. Patients received less physiotherapy and their length of hospital stay dropped from 22 to 13 days. The most salient finding of this study was the fact that a higher proportion of the patients who were sent to the nursing homes remained there a year after their discharge. A more recent British study provides further evidence for the usefulness of an active rehabilitation programme in promoting home discharge (Fox et al 1993).

Few studies have documented the cost-benefit of GORUs. A prospective study by Fordham et al (1986) indicated that joint geriatric and orthopaedic care was more expensive than traditional orthopaedic management.

In summary, although firm evidence from randomised controlled trials about the efficacy of GORUs is lacking the main body of literature does suggest that patients who have been managed in a GORU do regain their independence at a faster rate. The GORU patients are also less likely to be in more dependent forms of care both in the short and longer term.

#### **1.3.3.2.4      Early Supported Discharge Schemes**

In the Early Supported Discharge Schemes (ESDS) hip fracture patients are discharged back to the community at a relatively early stage of their rehabilitation process with augmented domiciliary support. Their subsequent rehabilitation occurs in their own homes. The rationale behind these schemes is to promote more efficient patient recovery and to provide a more cost-effective service by reducing the length of stay in acute hospitals (Sikorski et al 1985, Cameron et al 1993, Parker and Pryor 1993). The patients who are most suitable for these schemes are the ones who were resident in their own homes prior to their fracture as it is this group whose length of acute hospital stay can be reduced the most. The schemes do not apply to people in residential or institutional care as their length of hospital stay is very much determined by when their carers are prepared to have them return. The success of these schemes may be gauged in terms of the proportion of patients who are discharged back directly to their own homes and the length of their acute hospital stay. Outcome assessment however must also take into account how the patient manages at home and their recovery which would include consideration of any hospital re-admissions as well as the cost of care in the community.

Numerous schemes have been reported in the literature. They vary according to the selection criteria for entry into the schemes, the timing of discharge and the amount of community support that is provided. Much of the pioneering work for these schemes took place in Sweden in the late 1970's and early 1980's (Ceder et al 1980). Most of the schemes have a dedicated hospital team and a well developed community domiciliary support service.

The most radical of the ESDSs to be reported is the Queensland 'Rapid Transfer System' where patients were discharged home when they were able to walk (Sikorski et al 1985). 90% of the study patients were discharged back to their homes within five days of their fracture. Very selective criteria were used for entry into the study and the study did not state what proportion of hip fracture patients admitted to hospital were recruited into the scheme. Selection bias needs to be taken into account when interpreting the results. A



lower morbidity, in terms of post-operative complications and hip complications, as well as mortality was reported for the small series at three months post-operatively. Considerable savings in terms of bed-days was documented. An extension to this study was reported in 1993 by Sikorski and Senior. Thirty three percent of all hip fracture patients were deemed eligible for the accelerated discharge scheme. A re-admission rate of 11% was noted over the year following discharge and the authors state that most were for 'new medical problems' but did not specify the number which were due to hip fracture complications or rehabilitation problems. The authors go on to say that their complication rate was within the range reported by other studies. A mean nine day reduction in the length of hospital stay from 28 days to 19 days was noted using this scheme between 1985 and 1992 reducing the cost of management by 15%.

A very comprehensive ESDS has been operating in Peterborough since the late 1980's called the Peterborough Hospital-at-Home (HAH) Scheme for which 38% of all hip fracture patients have been eligible. The scheme has been carefully evaluated using a quasi-randomised controlled trial. Eligibility for the ESDS was determined blindly and then the patients were allocated to the ESDS or control group on the basis of their place of residence. Patients in the ESDS were observed to make a quicker functional recovery than patients treated conventionally (Pryor et al 1988, Pryor and Williams 1989, Parker et al 1991). In the HAH scheme a significant nine day reduction in length of hospital stay has been achieved with corresponding financial savings (Hollingworth et al 1993). A hospital readmission rate of 7% has been reported for patients in the ESDS over the year following the fracture compared to 3% of the conventionally managed patients. Re-admission rates at one month of discharge were 4% and 1% respectively. The readmission rates attained statistical significance. It should be noted however that because the patients in the ESDS were being discharged home earlier some of the complications that arose necessitating hospital re-admission would still have occurred had the patient still been in hospital.

Cameron et al (1993) have also recently reported the results for a randomised controlled trial evaluating an ESDS. To be eligible for the study patients had to have sustained a non-pathological fracture, have no other fracture, undergo surgery within seven days of

injury and live in a defined geographical area. Of the 252 consecutive patients who met the eligibility requirements admitted to a general hospital over a 21 month period 127 were randomised to be in the accelerated rehabilitation group. Patients were significantly younger in the treatment group but this difference was controlled for in multivariate analyses. Length of hospital stay was significantly shorter for the group of patients in the accelerated rehabilitation group compared to the control group with the mean length of hospital stay being 20 and 28 days respectively. A significantly improved rate of recovery as gauged by the Barthel Index was noted at two weeks and one month post-surgery in patients who had limited disability prior to their fracture but only a non-significant trend was noted when all the patients were included in the analysis. No significant difference in independence was noted at four months in the two groups. Significantly fewer patients in the treatment group originally from their own homes were discharged to a nursing home or died in the short term but the difference was non-significant at four months. The case fatality, re-admission and complication rates were not significantly different between the two groups. No complications were documented which were directly attributable to the accelerated rehabilitation programme.

Early supported discharge schemes for hip fracture patients have also been used elsewhere in Britain and Sweden and have noted that a higher proportion of patients are discharged directly back to their own homes. Currie (1994) reported an increase in the proportion of patients getting directly back to their own homes in Edinburgh within three weeks of their surgery from 9% in 1990 to 47% in 1993 with substantial cost-savings of the order of £400,000 per annum. Patient satisfaction with the scheme was high. Sixty nine percent of the patients thought they had not been discharged home too early whilst only 9% did with the remainder not knowing. Similar percentages about the timing of hospital discharge were obtained from the carers of hip fracture patients. The overall finding was that the patients and their carers were broadly happy with the ESDS. In a study using historical controls Holmberg et al (1989) reported that patients in their ESDS were discharged from the acute hospital significantly earlier and that they were less likely to be in institutional care at four months post-fracture, although this difference did not attain statistical significance.

Supportive work for the value of early discharge and home care has been reported in other areas of medicine. Functional and psychosocial recovery has been noted to be better and no increase in complications has been observed in surgical patients (Echeverri et al 1972, Gerson and Berry 1976, Gerson and Collins 1976).

#### **1.4 CLINICAL AUDIT**

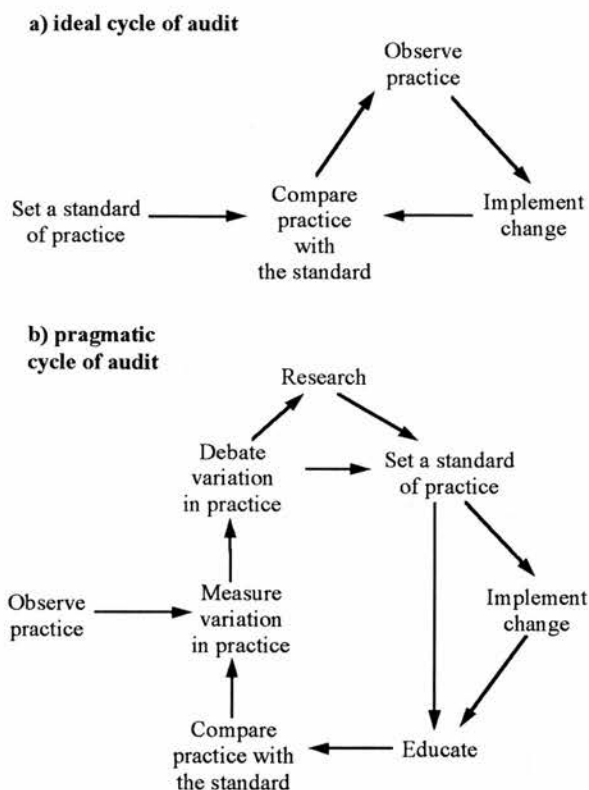
In this section background information on clinical audit will be given before discussing clinical audit in relation to hip fractures.

Clinical audit has formally been defined as

'the systematic, critical analysis of the quality of medical care, including the procedures used for diagnosis and treatment, the use of resources, and the resulting outcomes and quality of life for the patient' (Department of Health 1991).

Clinical audit is not usually considered as research though the boundaries are sometimes blurred. Audit aims to establish the extent to which actual clinical practice compares with the best clinical practice whilst clinical research is concerned with determining what is the best clinical practice (Clinical Research and Audit Group (CRAG) 1993). The contribution of research to clinical audit is illustrated in Figure 1.13. A cycle for the audit process has been identified and this is also shown in Figure 1.13. The initial task is to set standards followed by comparing current performance against those standards. Any shortfalls are then identified and the necessary action is then implemented as required. Performance is then reviewed in relation to the set standards. The standards themselves are kept under review and changed whenever necessary to achieve improvements in outcome.

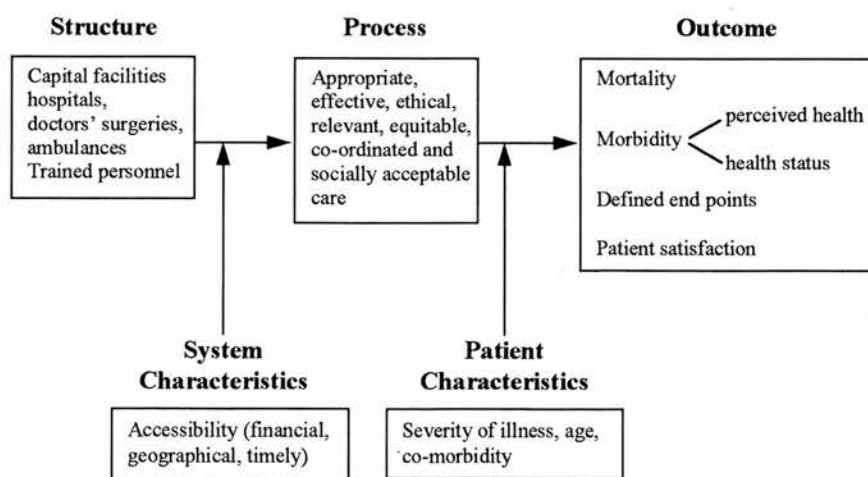
Audit should be extended beyond the individual patient to an organisational level and include the effectiveness and efficiency of the clinical care being provided. It is however difficult to assess the effectiveness and efficiency of treatment and the caring process. As a consequence of this, more emphasis is being placed on the development of clinical outcome measures to advance audit in health care. The three main categories of clinical



**Figure 1.13** The cycle of audit and related activities (Seaton et al 1994)

outcome. A working party in 1992 from the Scottish Clinical Resource and Audit Group (CRAG) stated that outcome measures should be reliable, valid and relevant. They also commented that the measures should relate to important areas of clinical care and should be sensitive to changes in structure, such as changes in staffing levels, and to processes such as the type of rehabilitation programme used, for example.

care, namely structure, process and outcome are shown diagrammatically in Figure 1.14 with further accompanying detail about the areas they cover (RCP 1990(a)). The most relevant indicator of the quality of patient care is outcome. Outcome refers to the change in the patient's current or future health that can be attributed to the clinical intervention (RCP 1990(a)). Apart from mortality, outcome measures may be difficult to define and at present are few in number and are of limited sophistication. Much audit has used the process of care as a proxy for



**Figure 1.14** Factors influencing patient outcome (RCP 1990 (a))

When assessing the outcome from different patient populations casemix needs to be taken into account to allow for any differences in their baseline characteristics which may influence their subsequent outcome. Greenfield (1989) defines casemix as

'the features that increase the risk of a bad outcome or influence the choice of treatment.'

Casemix may be viewed as having four major components : sociodemographic, for example age and social class; past or baseline functional status and well-being; disease specific severity; and comorbidity. The importance of casemix on outcome was clearly summed up by Hopkins in his review on medical audit (1991) when he categorically stated that

'characteristics of patients have more effect on variation of outcome between hospitals than does the quality of care'.

The importance of casemix on outcome in hip fracture patients is now beginning to be reported in the literature (Weatherall 1993(a)). Adjustment to allow for differences in casemix may be achieved through the use of prognostic indices for outcome measures. A recently published example of this is the CRIB index used for assessing outcome in neonates (International Neonatal Network 1993).

The importance of hip fractures to the NHS was recently made explicit in Scotland when the Clinical Resource and Audit Group (CRAG) selected this condition to be one of the six medical conditions to be audited in 1993. Selection was based on

'conditions, operations or events that are important in terms of the numbers of people affected and the level of resources committed to them'.

The outcome measures they selected for their audit were restricted to data that was available from the hospital discharge form that is completed for all patients, the Scottish Morbidity Record 1. The two specific clinical outcome measures that were selected for the hip fracture population were :

- i) deaths occurring within 30 days of admission as a percentage of all admissions
- ii) percentage of patients discharged home within two months of emergency admission from home

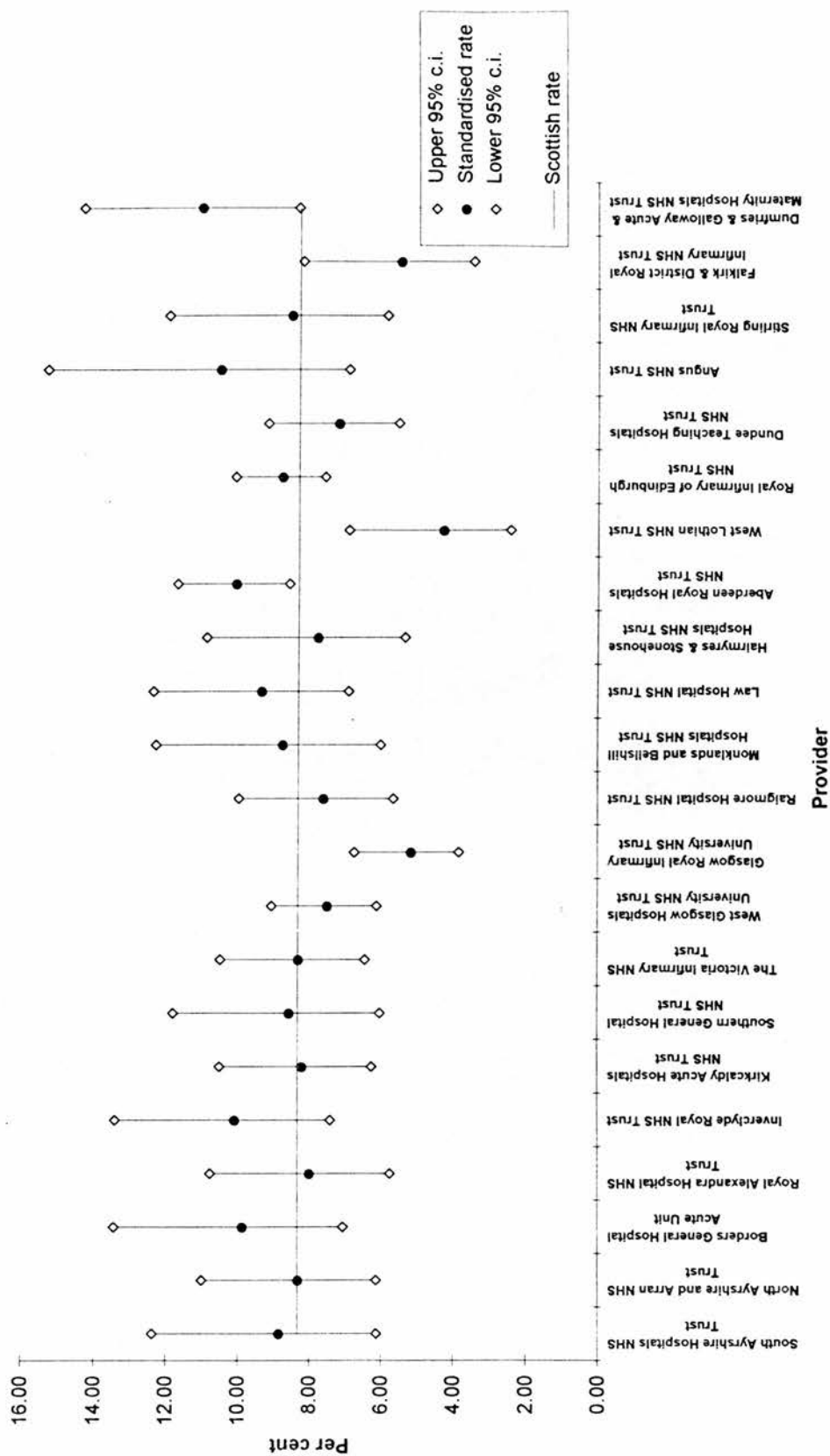
Further refinement of the accommodation indicator is required as at present 'home' is defined on the SMR1 record as being the 'usual address'. All places of residence other



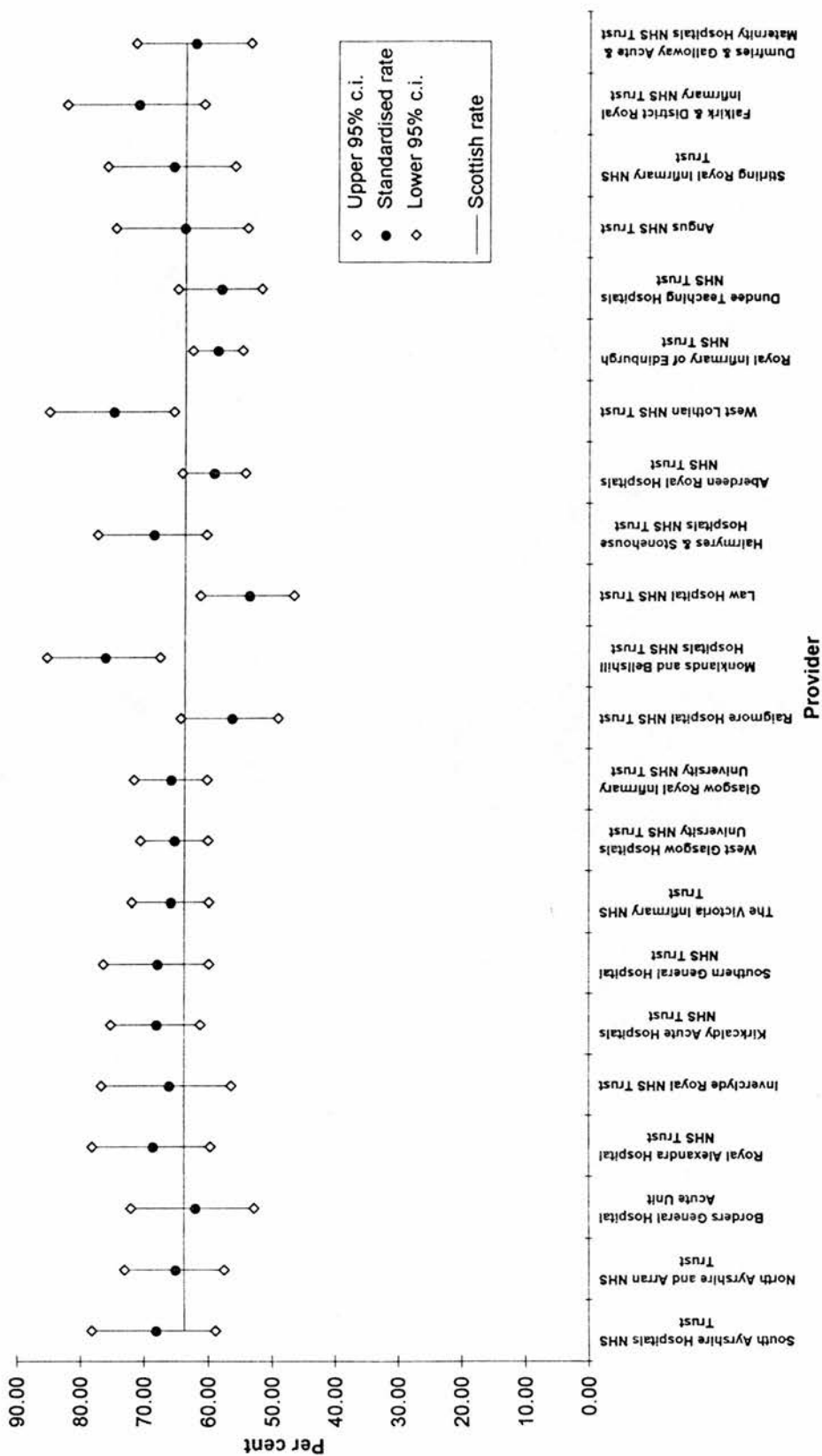
than NHS in-patient facilities are categorised as being 'home'. Consequently 'home' also includes sheltered housing, residential care and nursing homes.

The results for these two indicators are presented in Figures 1.15 and 1.16 and Tables 1.3 and 1.4. The standardised one month mortality rates ranged from 4.2% to 11.1% with the Scottish average being 8.3%. Two hospital trusts had significantly lower rates than the Scottish average whilst one had a higher rate. The standardised proportion of patients discharged back home within 56 days of emergency admission with a hip fracture ranged from 53.5% to 76.0% with the Scottish average being 63.6%. Two hospital trusts had significantly lower proportions discharged home than the Scottish average and another two were significantly higher. The need to take casemix into account for these two outcome measures has been recognised by CRAG so that the results may be interpreted more meaningfully (CRAG 1994). For both outcome measures comorbidity and place of residence prior to the fracture have been identified as being important casemix variables. Work is currently being undertaken to incorporate these predictor variables into the standardisation models used by CRAG (CRAG 1994). The indicator results are also influenced by the relative quality and completeness of the SMR1 data from the different hospital trusts.

Outcome measures need to be readily available if a particular system of audit is to become widely employed. For this reason, the assessment measures recommended by the joint working party of the RCP and the British Geriatrics Society (BGS) in 1992, should be considered given that their use will become widespread. These measures are detailed in the next chapter. If outcome measures such as dependency are introduced then thought will have to be given to their timing and how this will be done in practice. For example if the total Barthel score is used to assess dependency at two months after the fracture an assessment team will have to be available to do this as the majority of patients will no longer be in a hospital setting. CRAG have recently funded a specific hip fracture audit which is reviewing patient outcome at four and 12 months post-fracture (Currie 1993). A broad range of outcome measures are being assessed and these are : mortality, walking,



**Figure 1.15** Deaths occurring within 30 days of admission to acute Scottish hospitals as a percentage of all hip fracture admissions from July 1990 to June 1993 (CRAG (1994))



**Figure 1.16** Percentage of hip fracture patients discharged home from acute Scottish hospitals within 56 days of emergency admission from home from July 1990 to June 1993(CRAG (1994))



**Table 1.3** Deaths occurring within 30 days of admission to acute Scottish hospitals as a percentage of all hip fracture admissions from July 1990 to June 1993 (CRAG (1994))

Provider	Patients Admitted	Died within 30 days	Mortality rate	Standardised mortality rate	Lower 95% c.i.	Upper 95% c.i.
South Ayrshire Hospitals NHS Trust	367	34	9.26 %	8.84 %	6.12 %	12.36 %
North Ayrshire and Arran NHS Trust	588	48	8.16 %	8.29 %	6.11 %	11.00 %
Borders General Hospital Acute Unit	372	40	10.75 %	9.86 %	7.04 %	13.44 %
Royal Alexandra Hospital NHS Trust	563	42	7.46 %	7.96 %	5.74 %	10.77 %
Inverclyde Royal NHS Trust	467	47	10.06 %	10.07 %	7.40 %	13.40 %
Kirkcaldy Acute Hospitals NHS Trust	720	61	8.47 %	8.18 %	6.25 %	10.51 %
Southern General Hospital NHS Trust	445	37	8.31 %	8.55 %	6.02 %	11.80 %
The Victoria Infirmary NHS Trust	813	69	8.49 %	8.29 %	6.45 %	10.49 %
West Glasgow Hospitals University NHS Trust	1390	104	7.48 %	7.48 %	6.11 %	9.07 %
Glasgow Royal Infirmary University NHS Trust	1094	52	4.75 %	5.14 %	3.84 %	6.74 %
Raigmore Hospital NHS Trust	665	51	7.67 %	7.59 %	5.65 %	9.99 %
Monklands and Bellshill Hospitals NHS Trust	432	33	7.64 %	8.74 %	6.01 %	12.29 %
Law Hospital NHS Trust	546	49	8.97 %	9.35 %	6.91 %	12.36 %
Hairmyres & Stonehouse Hospitals NHS Trust	465	33	7.10 %	7.75 %	5.33 %	10.89 %
Aberdeen Royal Hospitals NHS Trust	1605	166	10.34 %	10.05 %	8.58 %	11.71 %
West Lothian NHS Trust	415	16	3.86 %	4.24 %	2.42 %	6.90 %
Royal Infirmary of Edinburgh NHS Trust	2157	192	8.90 %	8.76 %	7.57 %	10.09 %
Dundee Teaching Hospitals NHS Trust	842	63	7.48 %	7.18 %	5.52 %	9.19 %
Angus NHS Trust	254	27	10.63 %	10.52 %	6.92 %	15.32 %
Stirling Royal Infirmary NHS Trust	386	33	8.55 %	8.52 %	5.86 %	11.98 %
Falkirk & District Royal Infirmary NHS Trust	430	23	5.35 %	5.47 %	3.46 %	8.22 %
Dumfries & Galloway Acute & Maternity Hospitals NHS Trust	502	56	11.16 %	11.05 %	8.34 %	14.35 %
Scotland	17535	1458	8.31 %	8.31 %		

**Table 1.4** Percentage of hip fracture patients discharged home from acute Scottish hospitals within 56 days of emergency admission from home from July 1990 to June 1993 (CRAG (1994))

Provider	Patients Admitted	Discharged home	Proportion discharged home	Standardised proportion	Lower 95% c.i.	Upper 95% c.i.
South Ayrshire Hospitals NHS Trust	293	197	67.24 %	68.01 %	58.84 %	78.21 %
North Ayrshire and Arran NHS Trust	438	282	64.38 %	64.86 %	57.51 %	72.90 %
Borders General Hospital Acute Unit	284	166	58.45 %	61.80 %	52.75 %	71.96 %
Royal Alexandra Hospital NHS Trust	316	219	69.30 %	68.44 %	59.67 %	78.13 %
Inverclyde Royal NHS Trust	268	170	63.43 %	65.92 %	56.38 %	76.62 %
Kirkcaldy Acute Hospitals NHS Trust	549	374	68.12 %	67.91 %	61.20 %	75.16 %
Southern General Hospital NHS Trust	385	270	70.13 %	67.74 %	59.90 %	76.32 %
The Victoria Infirmary NHS Trust	721	473	65.60 %	65.66 %	59.88 %	71.86 %
West Glasgow Hospitals University NHS Trust	923	601	65.11 %	65.14 %	60.03 %	70.56 %
Glasgow Royal Infirmary University NHS Trust	768	528	68.75 %	65.68 %	60.20 %	71.53 %
Raigmore Hospital NHS Trust	388	217	55.93 %	56.27 %	49.03 %	64.28 %
Monklands and Bellshill Hospitals NHS Trust	359	288	80.22 %	76.02 %	67.50 %	85.34 %
Law Hospital NHS Trust	383	212	55.35 %	53.51 %	46.55 %	61.22 %
Hairmyres & Stonehouse Hospitals NHS Trust	356	254	71.35 %	68.47 %	60.31 %	77.44 %
Aberdeen Royal Hospitals NHS Trust	1002	572	57.09 %	59.07 %	54.33 %	64.12 %
West Lothian NHS Trust	296	231	78.04 %	74.79 %	65.46 %	85.09 %
Royal Infirmary of Edinburgh NHS Trust	1572	911	57.95 %	58.54 %	54.80 %	62.47 %
Dundee Teaching Hospitals NHS Trust	564	315	55.85 %	58.03 %	51.80 %	64.81 %
Angus NHS Trust	242	154	63.64 %	63.67 %	54.01 %	74.57 %
Stirling Royal Infirmary NHS Trust	271	173	63.84 %	65.42 %	56.04 %	75.94 %
Falkirk & District Royal Infirmary NHS Trust	242	174	71.90 %	70.96 %	60.80 %	82.33 %
Dumfries & Galloway Acute & Maternity Hospitals NHS Trust	312	190	60.90 %	62.00 %	53.50 %	71.48 %
Scotland	12224	7778	63.63 %	63.63 %		

freedom from pain, ability in the activities of daily living, patient satisfaction, community service uptake and residential status.

In summary, hip fracture patients are an important group of patients to audit. Further research is required into developing and refining existing outcome measures which take casemix into account to enable different hip fracture populations to be compared more meaningfully.

## **1.5 THE EDINBURGH HIP FRACTURE STUDY**

The current epidemic of hip fractures is placing an ever increasing burden on individuals and on the health and social services. Prevention of hip fractures at present offers little scope for reducing the number of fractures being sustained. As a consequence the most feasible option that is currently available to minimise the burden from hip fractures is to increase the efficiency of their management. Prognosis-based rehabilitation is viewed as being the most promising way of achieving this (Thorngren et al 1988, Ensberg et al 1993). It is the patients who are eligible for the early supported discharge schemes who offer the most potential for reducing the burden. Selection of patients for these schemes has traditionally been based on clinical judgement alone but more objective criteria are now being sought based on prognostic information.

Reviewing the literature it became apparent that most of the studies addressing outcome following a hip fracture had used a narrow range of outcome measures and few had related them to the pre-fracture status of the patient which is necessary to determine the real impact of a hip fracture (Magaziner et al 1990). Furthermore, most studies in the area had used a selected study population, with a low response rate, or had followed their patients up for a six month period only, or not followed their patients up serially post-fracture (Greatorex 1988, Mossey et al 1989, Magaziner et al 1990). A further difficulty with the published research was that a broad range of research instruments had been used making comparison of results difficult and none had employed all of the instruments and domains recommended by the joint working party from the RCP and BGS (1992).

Another limitation of many of the studies was that multivariate methods of analysis had not been employed.

On the basis of the literature review there was a need for a study to assess the outcome of an unselected population of hip fracture patients in a comprehensive way using standardised research instruments, at serial time points with minimal loss to follow-up, using multivariate methods of analysis. This coupled with the increasing need to manage hip fracture patients more efficiently, using prognosis-based rehabilitation, and the growing importance of clinical audit, as outlined earlier in this section, provided the impetus to perform the research which forms the basis for this thesis.

The Edinburgh Hip Fracture Study was a prospective longitudinal study which followed patients up for one year. The specific aims of the study were :

- i) To describe the distribution of outcome of an unselected cohort of patients with a hip fracture over a one year period, with respect to mortality and a broad spectrum of outcome measures covering medical, psychological and social domains. Management satisfaction was another outcome variable assessed in a sub-group of patients but will not be reported in this thesis.
- ii) To determine the relationship between measures of outcome at 1, 6 and 12 months post-fracture and the reported pre-fracture status of the patient.
- iii) To establish how these relationships can be used to obtain relatively simple indices for prediction of components of outcome which would be amenable to early clinical intervention or modification of the rehabilitation process.
- iv) To determine what combinations of the prognostic indices could be used to enable the meaningful interpretation of outcome for clinical audit purposes by allowing the adjustment for casemix differences.

The thesis will begin with a theoretical chapter on health measurement with particular emphasis on the health assessment of the elderly. The study methodology will then be outlined. This will be followed by the presentation of the baseline characteristics of the study population and their follow-up features. The derivation of prognostic indices for

selected one month and 12 month outcome measures will then be given. The thesis will conclude with an overview chapter which will : integrate the study findings; put them into context with the literature; suggest the clinical applications of the study results and their public health implications; and finally describe the further work that is still required.

## CHAPTER 2

### HEALTH STATUS ASSESSMENT

#### 2.1 INTRODUCTION

Traditionally measures of health have been based on biological indicators reflecting the three D's, namely death, disease and disability. Health-related thinking during the twentieth century has changed to encompass not only disease but functioning and well-being. This has been brought about by the demographic transition of the population, as a result of the declining birth rate and increased life expectancy, in conjunction with a change in disease patterns from acute to chronic diseases. There has also been a growing awareness over this century that health status and outcome can be influenced by a multiplicity of social and environmental factors (Hagart and Billington 1982). The importance of these factors is reflected by the new health status measurement instruments that are currently being developed (Greenfield and Nelson 1992).

Health care systems are additionally undergoing changes and there has been a shift in perspective from treatment of disease and counts of mortality to an insistence on outcomes being measured in terms of health functioning and well being (Johnston et al 1992). In Britain impetus has been added to the need to be able to assess health with the recent changes in the National Health Service (NHS). The introduction of clinical audit, resource management, and contracting for the provision of services have all contributed (Royal College of Physicians (RCP) and the British Geriatrics Society (BGS) 1992). A central premise of the new reforms is that the balance of health care is to be guided by health needs assessment of the populations served rather than by the historical patterns of provision. A review of each of the broad health care activities where purchasing authorities are expected to make informed decisions, reveals in most cases an impressive dearth of pertinent evidence (Frankel 1991). The emphasis on controlling health care costs over the past decade or so, not only in Britain but in all western nations, has created a particularly powerful stimulus for research into the effectiveness and efficiency of health services. This in turn has generated a wide range of measures designed in varying degrees to estimate the need for, and outcomes of, health care (Wilkin 1990).



At present the use of health measurement instruments in the NHS is limited and the necessary infrastructure is not yet in situ to ensure their successful introduction and usage. For example, the NHS and Community Care Act implemented in April 1993 stated that some form of assessment was required to ensure that the appropriate support and resources were delivered to the disabled elderly in the community (Department of Health 1990). However, few guidelines were given as to how this should be done. The RCP and BGS responded to this in 1992 by publishing a set of standardised scales for geriatric assessment.

This chapter will begin with a brief outline on how health is defined, with emphasis on the dimensions which are of particular importance to people over the age of 65, and is followed by a succinct review of why health should be measured. Health assessment scales are then reviewed and their areas of application, their advantages and disadvantages, and their psychometric properties are discussed. The important methodological issues encountered in assessing the health of the elderly are then considered. A detailed account of the health domains relevant to a hip fracture population follows as well as a review of the possible health assessment scales that could be used to measure them. Finally, the rationale for the selection of the research instruments used for the EHFS is given.

## **2.2 HEALTH**

### **2.2.1 Definition of Health**

The World Health Organisation (WHO) defined health in 1946 as

' a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity'.

This definition makes explicit the multi-faceted nature of health as well as the fact that there is a spectrum of health states ranging from disease to well-being. A more recent publication by WHO in 1989 which specifically reviewed health in the elderly recommended that seven different domains should be considered. These domains together with what they cover are as follows:

- i) Activities of daily living (ADL) - a) physical activities of ADL, that is, maintaining basic self care and mobility; b) instrumental activities of ADL, that is, being a functioning member of society and coping with domestic tasks.

- ii) Mental health functioning - cognitive; presence of psychiatric symptoms.
- iii) Psychosocial functioning - emotional well-being in a social and cultural context.
- iv) Physical health functioning - self-perceived health status; physical symptoms and diagnosed conditions; health service utilisation; activity levels and measures of incapacity.
- v) Social resources - accessibility of family, friends and a family/professional, voluntary helper.
- vi) Economic resources - income as compared to an external standard.
- vii) Environmental resources - adequate and affordable housing; siting of housing in relation to transport, shopping and public services.

The first five of these domains were included in the EHFS and are considered in more detail in section 2.6 along with the assessment instruments that may be used to measure them. The last two of the WHO domains listed do have important influences on health but governmental policy has an important bearing on them and consequently on the whole are not readily amenable to change in the short term by the caring professions. Furthermore if any changes did occur, such as alteration to taxes and benefits for example, regular review of specific questions would be required (RCP and BGS 1992). If such baseline information was incorporated into prognostic indices then they too would have to be reviewed and validated again to assess their usefulness. On this basis only one very general question about economic resources was included in the EHFS.

### **2.2.2 Impairment, Disability and Handicap**

Over the last few decades there has been an increasing interest in assessing the impact of disease on patients and their families. This has been brought about partly because of the change in emphasis from acute to chronic disease coupled with the demographic changes in the population. Health is now being viewed more in terms of impairment, disability and handicap. These terms have been defined by the World Health Organisation (1980) as :

**Impairment:** Any disturbance to the body's mental or physical structure or functioning. The impairment is characterised by a permanent or temporary loss or abnormality of



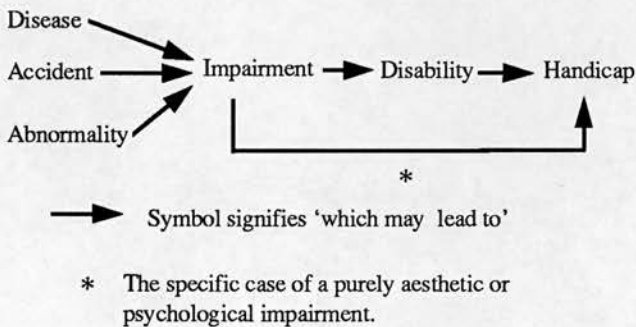
psychological, physiological or anatomical structure or function in a tissue, organ, limb, functional system or mechanism of the body.

**Disability:** Reduction or loss of functional capacity or activity resulting from an impairment. Disability is characterised by excesses or deficiencies of customarily expected behaviour or functions and represents the objectification of impairments through their effects on everyday activities.

**Handicap:** The disadvantage resulting from impairment and/or disability, entailing a divergence between the individual's performance or status and that expected of him by his social group. Handicap therefore represents the social and environmental consequences of impairments and disabilities.

The International Classification of Impairment, Disability and Handicap (ICIDH) avoids value judgements as to which consequences of disease are the most important and therefore may permit the clearer recognition of the impact of the disease. Medical models of health have historically tended to concentrate on impairment whereas patients are more concerned with disability and handicap.

The inter-relationship of impairment, disability and handicap is shown in Figure 2.1.



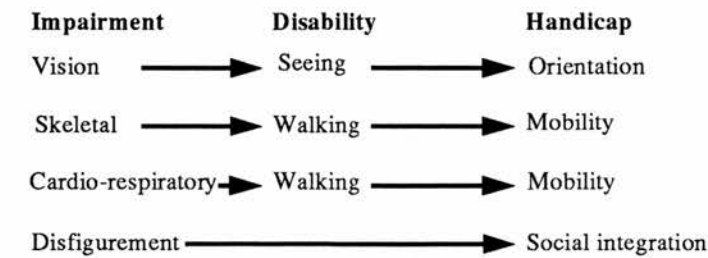
**Figure 2.1** Relationship between impairment, disability and handicap

Figure 2.2 gives examples to illustrate the relationship between the three dimensions (Martin et al 1988).

Although elderly people often have many impairments as a result of specific disease

processes as well as the general effects of ageing, the range of resultant disabilities is relatively small. A logical approach to their assessment is therefore to focus on disability. Additionally, disability is probably a key determinant of handicap and 'quality of life', and a

reduction in disability is the desired outcome and focus of many health care interventions (RCP and BGS (1992)).



**Figure 2.2** Examples of inter-relationships between impairment, disability and handicap (Martin et al(1988))

At present the measurement of impairment is the most developed primarily because it is the most straightforward of the three dimensions to quantify and because it has traditionally been the main focus of interest to the medical profession. Many health assessment instruments have been designed to assess disability. However no scales to measure handicap have been developed to date because of its subjective and multidimensional nature (Harwood et al 1992). Assessment scales will be covered in more detail in section 2.6.

## 2.3 REASONS FOR ASSESSING HEALTH

The reasons for assessing health may be considered at an individual patient level and at the population level. Health is assessed at the patient level in order to detect impairment and disability and to determine its severity. Assessment can also help in selecting treatment and other interventions as well as to monitor the effects of these interventions. At a population level health assessment helps define what is normal or typical (Ware 1992). It also facilitates the planning of the most appropriate health and social services to meet the needs of a population by quantifying the level of disease and disability within it. Measuring health also contributes useful information for clinical audit purposes and provides data that may be used for casemix adjustment (RCP and BGS 1992).

## 2.4 HEALTH STATUS ASSESSMENT INSTRUMENTS

### 2.4.1 Introduction

The instruments for health status assessment are questionnaires and interview schedules that provide health related information. They range from ad hoc questionnaires to

scientifically developed and validated tools. Some measure only one dimension or aspect of health while others seek to encompass a number of major health dimensions. The latter may provide a profile of health measurements or combine a number of measurements into one figure representative of overall health. More sophisticated and abstract health status measures may be constructed by combining data from a number of information sources (Hagart and Billington 1982).

Measures of outcome that do not refer to the disease or problem that may be causing poor health have been termed general or generic health status measures (Kantz et al 1992). Generic measures are expected to be sensitive to both the effects on health of a particular condition or intervention, and to the effects of any other condition affecting health status. They therefore permit comparisons of outcomes across groups of patients with different diseases. The development of normative data at both the local and national level must be developed so that clinicians can gain a sense of normal variation, and can see where their patients score relative to other patients.

The majority of assessment instruments measure only negative aspects of health, such as disability, which although important do not encompass all the dimensions of health as outlined in section 2.2. Increasing attention is now being given to the development of questionnaires that assess well-being. It is now accepted that health status scales should be able to place people accurately on a continuum from poor health to excellent health for a given health domain (Rubenstein et al 1988). The use of positively defined health measures is particularly important when studying general populations as only 15% will have chronic physical limitations and 10 - 20% will have a substantial psychiatric impairment. Consequently using a negatively defined instruments would reveal very little about 70 - 80% of the population. If a severely ill population was being studied on the other hand, it would be more appropriate to use instruments which emphasised the negative aspects of health.

The interpretation of health status scores can be influenced by four main factors. The first of these is patient mix, or casemix. Casemix, as outlined in section 1.4, may be viewed as

having four major components: sociodemographics; past or baseline functional status and well-being; disease specific severity; and comorbidity, which represents a summary of all the conditions that a patient may have, including the severity of pre-existing conditions (Greenfield and Nelson 1992). The second is the timing of the collection of the data which is a critical but often overlooked factor. For each outcome, and for each set of medical care processes delivered, there exists an optimum time window that is maximally responsive in a discriminatory sense to the care delivered. The third factor influencing the interpretation of health status scores is individual patient characteristics such as self-esteem, self-reliance, and other personality characteristics that are known to influence both compliance and patients' reporting of their functional status. Finally the measurement properties of the scale, particularly the scaling of the instrument, influences the interpretation of the score (Greenfield and Nelson 1992).

The emphasis on the rationing of health care resources makes the economic implications of the use of health status assessment instruments a salient issue when considering their benefit. If previously unrecognised problems are identified through health assessment then additional costs may be incurred by addressing them. This may be counterbalanced to some extent by the fact that savings may be accrued if future disability is delayed or institutionalisation is avoided. It is a complex area that still requires much research (Deyo and Carter 1992).

Studies on the value of health status measurement in clinical practice are few and sometimes contradictory. A few studies have shown that functional assessment and management of elderly patients by special geriatric teams can improve outcomes and achieve cost reductions (Lefton et al 1983, Rubenstein et al 1984, Liem et al 1986). Similarly comprehensive health status assessment when linked to plans of care, have been shown to improve outcomes and produce savings in home-based geriatric care (Tulloch and More 1979, Hendrikson et al 1984). However in a randomised controlled trial to assess the impact of a geriatric evaluation unit in a health maintenance organisation Epstein and colleagues (1990) failed to show that the outcomes of special care were superior to those with routine care. Also the use of general mental health and multidimensional health

status measures in primary care settings have not been demonstrated to improve the quality of care (Williamson et al 1964, Wells et al 1989). It has been observed that general practitioners fail to respond to the new information provided by health status assessment tools. Further work is therefore required to clarify the usefulness of health status measurement in clinical settings.

#### **2.4.2 Areas of Application of Health Assessment Scales**

The potential application of health assessment scales can be viewed as falling into three broad categories: discrimination, prediction, and evaluation. Measurement instruments may have one or more of these roles (Guyatt et al 1992, Kirshner and Guyatt 1985, Lansky et al 1992). The three categories will now be discussed in more detail.

Discriminant instruments distinguish between people where no gold standard, or external criterion, is available. An example of this type of instrument is the Abbreviated Mental Test which is designed to look at cognitive impairment (Hodkinson 1972). One of the most promising uses of these instruments is in surveys which attempt to quantify the burden of illness across different communities (Kirshner and Guyatt 1985). This will enable differences in health experiences to be described as well as a means of identifying need. Groups or areas where needs are greatest will be able to be targeted for selective allocation of resources.

Predictive or prognostic instruments attempt to classify individuals into a set of pre-defined measurement categories when a gold standard is available either at the time of the initial measurement or at some time in the future. Such instruments are generally used for screening or diagnostic purposes to identify specific individuals who have, or will develop, a target condition or outcome. In other words these instruments assist in identifying patients at greater risk of adverse physiological or psychological outcomes, patients in need of focused or supplementary therapies, and patients more likely to use health care services (Lansky et al 1992). Thus, for example, simple functional assessments may be used as indicators of need for services by elderly people in the community, because they are predictive of more detailed assessments by health and social care professionals, or of



successful outcomes, such as continued independent living. The Barthel Index (Mahoney and Barthel 1965) is one of the best known and widely used of the predictive functional assessment instruments currently available and is given in Appendix 2.

The third possible use for a health assessment scale is evaluation. These instruments measure the magnitude of longitudinal change in the parameter of interest. The scales can be used at either an individual or a group level. Survival rates and cure rates are classic measures of medical outcome for evaluative research, but many measures of health such as quality of life are also intended for use as evaluative criteria. An example of an evaluative instrument would be the Harris Scale which can be used to look at functional outcome following a total hip replacement (Harris 1969). The Harris Scale is given in Appendix 2.

### **2.4.3 Advantages and Disadvantages of Health Assessment Scales**

#### **2.4.3.1 Advantages**

Standardised assessment scales may encourage a more comprehensive assessment of patients. Severe impairments are correctly identified using clinical judgement alone but the more prevalent moderate impairments in areas such as mental state, vision and continence are poorly recognised on the whole (Pinholt et al 1987). They may permit earlier detection of illnesses that may be more advantageously treated at an earlier stage and perhaps enable better differentiation of physical from emotional disability (Nelson and Berwick 1989).

The use of the scales may improve the communication between multidisciplinary professionals. A common clinical language and descriptors of disability may develop with the widespread adoption of the scales. Their use should also have an educational value and enhance the training of all the professionals who come into contact with elderly people (Dunn et al 1987, Dickenson and Young 1990, RCP and BGS 1992).

The use of standardised assessments should facilitate the planning of health and social services by helping to quantify the prevalence of disease and disability. The scales should also be useful in clinical audit by increasing the uniformity of the data collected so that

outcome can be assessed in a more objective way. They should also allow casemix to be assessed more effectively in different populations and permit the effects of intervention to be determined more meaningfully. However it should be noted that most of the scales are unproven as casemix or outcome measures. Additionally the responsiveness of scales is often only poorly known. This will be discussed further in section 2.4.4.4. The links between scale scores and resource use is similarly unknown but the potential to model resource utilisation may prove to be of benefit (RCP and BGS 1992).

Good health status measures could perhaps decrease the amount of time spent by clinicians in gathering information from patients by asking the 'right' questions and make use of otherwise unproductive patient waiting time. For some tools, staff other than clinicians could supervise the collection of the information, perhaps increase their productivity, their sense of professionalism, and their job satisfaction. It is also plausible that properly constructed instruments could be enjoyable for the patient to complete. They could be interpreted by the patient as a sign of thoroughness and attentiveness on the part of the clinician and perhaps increase patient satisfaction. The measures may also be self-documenting in that they may add to the consistency, legibility and retrievability of medical record information.

#### **2.4.3.2 Disadvantages**

The enormous variety of health status measurements creates a significant impediment to their immediate and widespread acceptance in routine care (Lansky et al 1992). Furthermore the scales that are available may not cover all the aspects of interest and may consequently need to be supplemented with individual questions. Also many of the health scales emphasise the negative end of the health continuum resulting in a substantial loss of health information (Ware 1987). The use of scales may be further limited by their length and restricted sensitivity. The more rigorous instruments tend to be longer and may be quite time consuming and consequently may not be practical to use if a number of research instruments are going to be used concurrently. Using a structured interview also means a loss of the flexibility of the testing procedure, an inability to probe problems in detail, as

well as missing the opportunity for the synthesis of findings to develop a global impression (National Institutes of Health 1988).

Difficulties are also posed by the fact that the use of assessment scales requires knowledge of normative data and the health status variability in populations and this data is not presently available. The lack of the necessary computing facilities in clinical settings compounds this problem and may prevent any significant progress being made with the compilation of the required databases. Difficulties also arise from the interpretation of the levels of measurement derived from assessment scales as well as the clinical meaning of a unit of change (Greenfield and Nelson 1992). Further research is needed into the extent to which the values attached to health states are similar in different cultures or social groups so that a more meaningful interpretation of health scores can be made (Patrick et al 1985).

Other problems with the use of standardised assessments is that they may provoke unwarranted patient anxiety if the results from a screening assessment is a false positive. There may also be fears of inappropriate medicalisation of old age when performed routinely in elderly people. The use of assessment scales may also threaten confidentiality because of their multidisciplinary nature as well as their use in communicating information in dealing with multiple non-medical agencies (RCP and BGS 1992).

The introduction of standardised assessment may meet with resistance from clinicians as they may see it as being a threat to their autonomy. Clinicians in some specialities with a history of functional measurement, as in orthopaedics for example, have a higher regard for health status measures than those practising in areas with a historical focus on physiological standards such as oncology for example. Clinicians may also lack confidence in the information provided, doubt whether they can help the patient, or be worried by the increased workload and cost the administration of these scales would impose. Furthermore in a clinical setting staff are minimally available for data collection and make it a low priority compared with other obligations. They also may lack the skills to conduct careful data collection and may lack the patience for exploratory data analysis (Lansky et al 1992).



#### **2.4.4 Parameters of Health Assessment Scales**

The terminology used to define the properties of research instruments is not straight forward. Guyatt et al (1992) sum up the situation very clearly in the following words:

'The health status measurement literature is a jungle. Students in the area (whether fledgling graduate students or experienced researchers) must hack through an underbrush of confused terminology and contradictory conceptualizations. Many get lost; some, presumably consumed by large carnivores, are never heard from again.'

In this section the psychometric properties of assessment scales will be discussed. The qualitative properties will precede a more detailed review of the quantitative properties. It should be noted that the suitability of a scale encompasses both qualitative and quantitative properties. The quantitative attributes of this property are outlined in section 2.4.4.2. Construct validity is used to evaluate sensibility in quantitative terms and further detail on this may be found in section 2.4.4.3.1. The responsiveness of scales to clinically important change will also be reviewed as well as the floor and ceiling phenomena that may be encountered when using scales.

##### **2.4.4.1 Qualitative Considerations**

Feinstein (1987) divided qualitative considerations of health assessment scales into five main areas as follows :

- i) Purpose and framework - covers clinical function, justification, and applicability.
- ii) Overt format - covers comprehensibility, replicability, and suitability of the output scale.
- iii) Content validity - refers to the idea that all items should be relevant and that a comprehensive coverage of all the important aspects of the concept being measured has been made (Wilkin and Thompson 1989, Fallowfield 1990, RCP and BGS 1992).
- iv) Face validity - examines whether or not the items within the test appear, on subjective evaluation, to be asking questions relevant to the purpose of the test (Fallowfield 1990). It is one form of content validity (Bowling 1991, RCP and BGS 1992).

- v) Ease of usage - must be practical to use. Indicators of respondent burden include refusal rates, rates of missing responses and administration time (Ware et al 1981).

Further details are beyond the scope of this thesis but may be found in Feinstein's book on Clinimetrics (Feinstein 1987).

#### **2.4.4.2 Quantitative Considerations**

The more scientific aspects of health status measures will now be discussed. Validity will precede reliability.

##### **2.4.4.2.1 Validity**

In general the term validity can be defined as referring to the extent to which a measure assesses what it claims to measure. More formally, validity indicates the range of inferences that are appropriate when interpreting the scores obtained from a given measure. Although measures are often simply described as being valid or invalid, validity is neither a unitary nor an absolute concept. Relative confidence in the validity of a given measure is based on the accumulation of several types of empirical evidence (Feinstein 1987, McDowell and Newell 1987, Wilkin and Thompson 1989, Bowling 1991).

The main type of validity is criterion validity, also known as empirical or statistical validity, and it refers to the extent to which a measuring instrument produces the same results as a gold standard, or criterion measure (Kirshner and Guyatt 1985, Bowling 1991). In many cases, such as the measurement of functional status or quality of life, a gold standard is not available. Under these circumstances investigators must show that all relevant aspects of the domain or the area they are trying to measure are represented (content validity), and that the new instrument relates to other tests or measures in the way one would expect if it is really measuring what it is meant to measure (construct validity) (Guyatt et al 1987). Construct validity examines the relationship between the results obtained using the health measurement scale and the theoretical constructs on which it is based. It may be hypothesised for example, that a persons level of dependency increases as they age. A positive correlation between dependency scores and age would support the hypothesis and

thereby provide some evidence of validity (Kaufert 1983, Kirshner and Guyatt 1985, Wilkin and Thompson 1989). Construct validity can also be examined by looking at the internal structure of the instrument. This can be done statistically by looking at the extent to which each item correlates with the scale as a whole. One of the most common methods used to achieve this is factor analysis. If the items are correlated with one another then this indicates that the instrument is looking at a single dimension (Wilkin and Thompson 1989, Fallowfield 1990).

There are various types of validity which are related to criterion validity and they will be mentioned here briefly for completeness and because they are used in Appendix 3 which lists the properties of specific health assessment scales. Firstly, there is concurrent validity which is used when the health measurement instrument and the standard criterion measure are performed at the same point of time and are then compared. The success of this method depends on the extent to which the standard measure itself is a valid instrument as well as to the extent to which the two measures look at the same concept (Wilkin and Thompson 1989). If the criterion result is obtained at a future date rather than concomitantly the relationship to the criterion measure is called the instrument's predictive validity (Feinstein 1987, Bowling 1991). The term convergent validity applies when the instrument produces similar results to an established scale measuring the same concept and dissimilar results to an established instrument measuring a different concept (RCP and BGS 1992). For example, if theoretical considerations suggest that depressed subjects will perceive their level of social support to be lower than non-depressed people, then scores from scales measuring these two dimensions should be correlated.

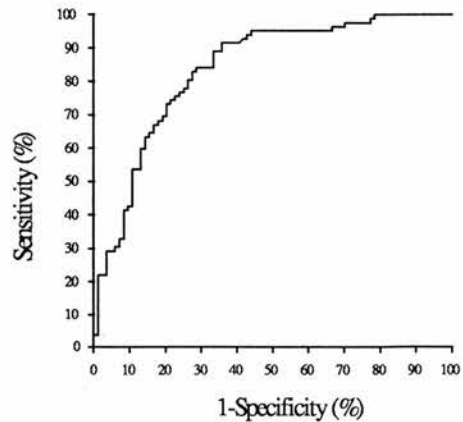
Concurrent validity may be evaluated in terms of the rating scale's capacity to classify patients into normal/abnormal categories. The utility of a rating scale to do this is usually determined to some extent by how closely it conforms to some reference measure. The results of such a comparison are expressed in terms of the instruments sensitivity and specificity (Bennett and Ritchie 1975). These terms will be expanded upon because the usefulness of selected regression models in the EHFS were assessed in this way. Refer to chapters 5 and 6.

Sensitivity has been defined as the proportion of truly diseased persons in the screened population who are identified as diseased by the screening test. It is a measure of the probability of correctly diagnosing a case, or the probability that any given case will be identified by the test. Specificity is the proportion of truly non-diseased persons who are so identified by the screening test. It is the probability of correctly identifying a non-diseased person with a screening test (Last 1988). An instrument's sensitivity and specificity are both related to its content and construct validity as they are both involved with the correct identification of different populations of patients (Fallowfield 1990).

Sensitivity does not imply specificity as one is gained at the expense of the other so that the determination of the reference standards or 'cut-off' point, that is the point below which all cases are said to be negative and above which all are positive, becomes a difficult problem. The designation of a cut-off point usually involves a degree of error as symptoms are rarely simply present or absent, but lie along a continuum from positive to negative. The errors incurred by the inaccuracy of the cut-off point are termed false negatives and false positives. Typically a cut-off point is proposed that maximises the combination of sensitivity and specificity desired and this is usually done through a system of trial and error and necessarily involves multiple looks at the data. When screening, sensitivity (avoiding false negatives) may be more important than specificity (avoiding false positives) so lowering the cut-off point to the lower limit would be beneficial. Opportunities for clarifying the status of false positive patients will arise but the false negative patient is lost to further scrutiny (RCP and BGS 1992). In research situations, such as a disease prevalence study for example, it is usually better to raise the cut-off point to its uppermost limit to lower the risk of false positives which would exaggerate the findings.

Another way to express the relationship between sensitivity and specificity for a given test is to construct a curve, called the receiver operator characteristic (ROC) curve which is coming into increasing use as a method of examining the clinical performance of a test (Burke et al 1989). The curve is constructed by plotting the true positive rate (sensitivity) against the false positive rate (1-specificity). It shows the trade-off between sensitivity and

specificity for a test and can help decide where the best cut-off point should be (Fletcher et al 1988). See Figure 2.3. For example, Yesavage et al (1983) found using a cut-off value of 11 for the detection of dementia with the long version of the Geriatric Depression Scale yielded a sensitivity of 92 - 95% and a specificity of 84 - 89%. When this was raised to 14 the trade off between sensitivity and specificity was very evident with the former rising to 100% whilst the latter fell to 80%. It should also be noted that the overall accuracy of a test can be described with ROC curves and it is represented by the area under the curve (AUC). The larger the AUC the more accurate the test (Fletcher et al 1988). A test which produces little useful information will yield a diagonal line. The AUC were derived for selected outcome measures in the EHFS and the results can be found in chapters 5 and 6.



**Figure 2.3** Receiver operator characteristic curve (Fletcher et al (1988))

#### 2.4.4.2.2 Reliability

Reliability may be defined as the ability of an assessment instrument to repeatedly obtain the same measurement in the absence of real change. It is the degree to which the measure is free from random error. It may be thought of as the ratio of the 'signal' to the 'noise' in a medical test (Guralnik et al 1989, Wilkin and Thompson 1989). Reliability is an important issue for the EHFS and will consequently be described in some detail.

The appraisal of reliability is often regarded as being a separate act of evaluation, different from what is done to appraise validity. Nevertheless when critics or potential users ask if an index has been validated they usually want to know about reliability as well as the other aspects of validity. The basic idea behind the question is that an inconsistent index will not be valuable or useful regardless of how well it scores in any other tests of validity (Feinstein 1987). Ware et al (1981) noted however that most publications about health status measures report little or nothing about reliability. When it is given reliability is often expressed in terms of a reliability coefficient. This coefficient indicates the proportion of



information rather than random error or bias that a score contains. A coefficient of 0.80, for example, means that the score contains 20% random error or bias. The reliability of the instrument may be influenced by various factors such as the inclusion of ambiguous items in the questionnaire (Bennet and Ritchie 1975).

For the statistical assessment of reliability it is useful to subdivide reliability into internal and external reliability. Internal reliability refers to the internal inter-relationships of the component elements of the index. It is the degree to which responses to similar items or questions within the assessment being evaluated correlate with each other (Applegate 1987). These inter-relationships can be considered for two different attributes namely performance consistency and internal homogeneity (Feinstein 1987). Performance consistency refers to the performance of the individual items contained in different parts of the index or in repetition of the index by the same user. It may be assessed using the split-half method, the test-retest method or the alternate form method. Detail about these methods are outwith the scope of this thesis but the reader is referred to the work of Bowling (1991) for further reading. The internal homogeneity of an instrument reflects the correlation between the different components of the index and may be assessed using Cronbach's alpha.

The external reliability of a measurement scale refers to the external observer variability with which an index is applied on different occasions by the same user or other users. The intra-observer reliability refers to the variation observed when the same observer repeats the index on the same patient. Inter-observer reliability is the term used to describe the variability when more than one observer administers the instrument to the same subject. It can be crucial for instruments used in clinical practice since staffing patterns frequently require that different raters will use the instrument at different times (Feinstein 1987). Assessment instruments which rate characteristics which are difficult to define, or which require subjective ratings, have particular problems with inter-rater reliability and extensive staff training is often necessary to ensure adequate reliability (Applegate 1987). Instruments which use carefully worded questions are likely to achieve more reliability between different raters. Reliability may also be affected by the use of different informants

as the explicit or implicit purpose of the instrument may influence the response. This is particularly salient for the EHFS as a considerable number of patients were not able to provide their own information and an informant had to be recruited on their behalf. To address this issue a nested validation study formed part of the EHFS and further detail about this is given in section 3.5.4. The reliability of responses may also be affected by the surroundings in which the assessment was conducted (Wilkin and Thompson 1989). The statistical approach to analysis for assessing reliability is very much dependent on the type of data collected. For categorical data for example, Cohen's kappa coefficient may be used and for numerical scales Pearson's correlation coefficient may be employed. Further detail about these methods of analysis may be found in section 3.7.1 as they were utilised in the EHFS. The simplest way to assess the agreement between two observers is to look at the percentage agreement. This method however makes no allowance for chance agreement and can therefore be spuriously high. If more than two raters are used variability can be assessed using the intraclass correlation procedure or Kendall's index of concordance (McDowell and Newell 1987).

#### **2.4.4.3            Responsiveness of Scales to Clinically Important Change**

The responsiveness of a test is directly related to the magnitude of the change in the patient's score which constitutes a clinically important difference (Guyatt et al 1987). The minimal clinically important difference can be defined as the smallest difference in score in the domain of interest which patients perceive as beneficial and which would mandate, in the absence of troublesome side effects and excessive cost, a change in the patient's management (Jaeschke et al 1989).

The development of many measures of health have emphasised validity rather than responsiveness and because of this there is often inadequate information on how useful responsiveness is in evaluative research. In fact the usual preferred methods of establishing reliability and validity tend to militate against responsiveness. They tend to focus on the ability to discriminate between individuals or groups, or correlations with other measures and internal consistency as mentioned in section 2.4.4.3. Measures which are good at discriminating will tend to have very limited response categories to minimise



the problem of respondents placing different interpretations on response categories. They will also tend to keep the number of items to a minimum in order to maximise internal consistency. In contrast, a measure which is responsive to small changes over time in the same individuals may require a more refined grading of response items and the inclusion of any item which may show a change. Such a measure may be poor at discriminating between groups in that it may exclude items which are good discriminators but are not amenable to change, and it may include others which only affect a few respondents or are treated inconsistently. Nevertheless it may function well as a measure of change in individuals (Wilkin 1990).

Information about responsiveness of the scales used for the EHFS was very limited as may be seen from Appendix 3.

#### **2.4.4.4 Floor and Ceiling Phenomena**

A scale should be capable of detecting change due to intervention or over time at all levels of the scale. However a scale may not be able to detect meaningful differences between subjects who score at the bottom or top of the scale and this is called floor and ceiling effects respectively (RCP and BGS 1992). They are probably more common with shorter assessment scales (Bindman et al 1990).

The floor effect is more important than the ceiling effect in practice. It leads to a bias in documenting the decline in health of severely ill patients and this is the group in which it may be the most important to detect it. It is not clear how to interpret the responses of patients at the floor of a health dimension scale (Bindman et al 1990).

The ceiling effect is less worrisome as investigators are rarely trying to document improvements in health for those in whom it is already excellent (Bindman et al 1990). One way of mitigating the ceiling effect is to use another scale in those patients with a high score in order to detect less severe grades of impairment. An example of this relevant to the EHFS would be to assess the instrumental activities of patients who scored highly on a

scale which assessed primary activities of daily living such as the Barthel Index (RCP and BGS 1992).

## **2.5 METHODOLOGICAL RESEARCH ISSUES IN THE ELDERLY**

In the EHFS only patients aged 60 years or older were recruited into the study. It is therefore relevant to consider some of the difficulties that are encountered in conducting research in this age group. The section will begin with a discussion on obtaining informed consent in a geriatric population followed by issues about data collection and the source of the data.

### **2.5.1 Consent**

Participation in a study requires voluntary consent and this has been stated in the Nuremberg code of 1949 as follows:

'The voluntary consent of the human subject is absolutely essential. This means that the person involved should have legal capacity to give consent; should be so situated as to be able to exercise free power of choice, without the intervention of any element of fraud, deceit, duress, over-reaching, or other ulterior form of constraint or coercion; and should have sufficient knowledge and comprehension of the elements of the subject matter involved as to enable him to make an understanding and enlightened decision. This latter element requires that before acceptance of an affirmative decision by experimental subject there should be made known to him the nature, duration, and purpose of the experiment; the method and means by which it is to be conducted; all inconveniences and hazards reasonably expected; and the effects upon his health or person which may possibly come from his participation in the experiment.'

This statement provides a useful outline of the conditions necessary for consent by the majority of study patients. It does not however cover groups of patients whose ability to give consent is impaired such as occurs in patients with dementia(RCP 1990(b)). This poses obvious problems for research involving elderly subjects including the present study.

In general, it should be assumed that elderly patients are competent to give consent unless there is evidence to the contrary (RCP 1990(b)). Where competency is in doubt, or absent, a procedure which seeks what is in effect a mixture of consent by the patient and a relative or nominated individual who knows the patient well may be an ethically supportable option. The patient should be provided with as much information as possible

and the most competent consent obtained. Where impairment is so marked as to render this not feasible, a neutral attitude on the part of the patient with failure to object is deemed to be acceptable for consent. No patient who refused, or if incapable of refusing resisted, should be included in or continue in research. A near relative or nominated individual, known as a proxy, should be informed of the nature of the research and the details of what is involved and should agree to the patient being enrolled into the study. The identification of an appropriate proxy, and under what circumstances one person can give consent for another's participation are issues which require further clarification (Warren et al 1986). Elderly patients who are in long-stay accommodation require special consideration when obtaining their consent as they are more dependent and vulnerable group on the whole. Their dependent relationship in an institution may make it difficult for them to decline to participate (RCP 1990(b)). It should also be borne in mind that there is a need to weigh the rights of an individual who is unable to consent against the need to advance the knowledge and treatment of the condition under investigation (RCP 1990(b)).

### **2.5.2 Data Collection**

The issues raised in this section were considered at the design stage of the EHFS and steps were taken to minimise any methodological difficulties where this was possible.

Most elderly people are capable of completing a self-administered questionnaire although some cannot do so because of cognitive impairment, language or literacy problems or because of various other handicaps. This mode of administration takes less interviewer time but elderly people often consult family members about the questions, resulting in consensus responses that may not accurately reflect the patient's own opinion. Some evidence also suggests that the response rates to questionnaires is particularly low in the elderly (Herzog and Roger 1988). Reasons for refusing to participate include not feeling well, a general suspicion of studies, concern about signing a paper such as the consent form, and in a hospital setting, anxiety about being in hospital and a feeling that enough questions have already been asked by hospital personnel (Kelsey et al 1989). Other research however has indicated that the changes in cognition and personality that occur with ageing results in the elderly person assuming a more passive role which has the effect

of increasing compliance (Stanley et al 1984). It has been recommended that personal interviews be performed in order to obtain higher response rates amongst the elderly (Fillenbaum 1984). Other ways of improving response rates include the use of an informant to provide information on the patient's behalf where necessary; conducting the interview with a relative present; to emphasise that the clinician has given the interviewer permission to speak to them and that the interviewer is working with their clinician. Additionally stating that their general practitioner's consent has been sought and that they are agreeable to them participating in the study improves the response rate. Also showing concern for how the patient is feeling and returning on another occasion if the person is not well enough to be interviewed has also been reported to reduce the number of refusers (Kelsey et al 1989). All of these approaches were adopted in the EHFS.

In patients less than 75 years of age a questionnaire that takes an average of one hour to administer can be used in most population groups. Fatigue however tends to set in after about half an hour with people over 75. Many of the very elderly can persevere for up to 45 minutes, provided they are in reasonable health, but interviews that extend beyond this may cause the respondent to terminate the interview in frustration or to give inaccurate and unreliable information. To overcome this problem the interviewer could either complete the interview at a later date if feasible or shorten the questionnaire (Kelsey et al 1989). In the EHFS the initial interview took around one hour to complete. Patients were revisited if there was a complicating medical factor which interfered with data collection, if the patient was obviously tiring, or if the patient simply requested another interview time.

Visual and hearing problems are both common and important in the elderly and may present substantial barriers to communication and were considered at the design stage of the EHFS. Anything to be read by the elderly in the EHFS was in very large print and clear, direct speech with frequent repetitions was used by the interviewer for patients with hearing problems. Extra time for the completion of the interviews was allowed for to help minimise the impact of these problems. Other factors such as memory deficits, medical problems, a lack of familiarity with research studies and a tendency not to be able to recognise when precise detail is needed, and when it is not, were also recognised as

potentially contributing to a questionnaire taking a longer time to administer to an elderly person than it would to a younger adult. Rambling was in fact found to be particularly troublesome in the EHFS as many of the patients were very elderly and were quite isolated and appreciated the opportunity to talk. The required information was often lost in the course of digressions. Patients may also become too fatigued by the irrelevant conversation to provide accurate information on the variables of interest to the interviewer (Kelsey et al 1989).

Elderly patients admitted to hospital are often confused and this was an important problem for the EHFS. A study by Magni et al (1988) of elderly surgical patients reported that as many as 25% develop an acute confusional state. As previously mentioned in this section any factor that affects the patient's level of cognition will add to the error of a questionnaire. As a consequence it is desirable to wait for several days after hospitalisation before interviewing the elderly patient so that the majority of acute confusional states have resolved (Gustafson et al 1988). Other factors, such as the patient being in considerable pain at the time of their admission, may necessitate postponing the interview until the patient is more settled. These hospital associated factors were particularly relevant to the data collection in the EHFS.

It is also worth recognising that among elderly hospitalised patients depression is also a major cause of diminished cognitive function with consequent effects on the quality of the information obtained. The effect of the stress of hospitalisation for an elderly person combined with the anxiety of wondering what will happen to them after discharge often predisposes them to episodes of depression (Billig et al 1986, Magni et al 1988).

Another methodological consideration in the elderly is that specific information may be required on only a particular sub-group of patients, such as the cognitively intact for example, who may only be identifiable after the initial information has been gathered. To achieve this, sampling in two stages should be considered, with the first stage acting as an identifying screen and the second focusing on the persons identified (Fillenbaum 1984). This approach was necessary in the EHFS.



The general issue of bias is an important consideration when collecting data from any study population and because of this it will be discussed very briefly here. Bias refers to any deviation from the true situation (Last 1988). It may be introduced through either the interviewer or the respondent. The largest source of interviewer error is through the use of subsidiary questions or probes to clarify the respondents initial replies. It can also arise from stressing particular words which may change the meaning of an item. Interviewer drift also contributes to bias because the more times an interviewer uses a questionnaire efficiency may wane and he/she may cease to uphold the standards held initially. To minimise interviewer bias standardisation of the interview procedure is required as well as regular feedback on performance. There are various types of bias relating to the respondent. A positive 'halo-effect' occurs as a result of respondents over-estimating the qualities which they feel are desirable due to an overall favourable impression of the person or situation about which the question refers. 'Response set' biases describe the tendency of a respondent to persistently respond in a particular way regardless of the question content. The first of these is acquiescence bias where respondents tend to give positive responses such as 'true', 'often' or 'yes' to questions. End aversion, or central tendency bias, is where people are reluctant to use the extreme categories of a scale. If responses are consistently made towards the favourable end of a continuous scale a positive skew occurs. This produces a ceiling effect as it is almost impossible to detect any improvement or to distinguish between various grades of excellence. To minimise response bias questionnaire design is of paramount importance. Methods such as including 'throw away' categories at the end of scales that are on a continuum or not putting 'average' in the middle of a scale for example may be of help (Bennett and Ritchie 1975, Streiner and Norman 1989).

### **2.5.3 Source of Data**

Interviews with proxy respondents are important in studies of the elderly as excluding patients who are deemed not competent to give informed consent may substantially reduce the study sample size and its power and introduce bias. This was an issue of considerable importance for the EHFS as cognitively impaired patients, as indicated by their baseline Abbreviated Mental Test scores, accounted for 34% of the total study population. Their inclusion enabled the study size to be increased by 63%. A study by Magaziner et al

(1988) showed that enlisting the co-operation of proxy respondents increased the sample size by 71% in their prospective study of outcome in hip fracture patients. The usefulness of this increase in the number of eligible patients for use in a study by utilising proxies is counterbalanced to some extent by the fact that proxies may have higher rates of non-response to particular questions than patients which effectively may reduce the sample size for any given characteristic under study. More subjects may also be required if proxies are used because of a loss of the precision needed to achieve a given level of statistical power (Nelson et al 1990).

By being able to retain patients in a study by using a proxy to provide information on their behalf means that a more representative group of individuals with the disease of interest will be obtained (Nelson et al 1990). The reason for the inability of the patient to give informed consent in fact may predispose to the disease under study. Cognitive impairment, for example, may increase the risk of sustaining a hip fracture and if this group of patients is excluded from the study then the association between cognitive impairment and hip fracture cannot be examined (Kelsey et al 1989).

To clarify whether proxies can in fact provide useful information for frail or demented elderly patients it needs to be known whether the responses of the patients and proxies are highly correlated. This would provide information on concurrent validity, which was discussed in section 2.4.4.2.1, and would indicate whether the proxy is a reliable substitute for the patient. Studies that use proxies instead of patients should demonstrate a high correlation between patient and proxy responses for this approach to be acceptable methodologically. It should be remembered that significant mean differences can exist between two variables even when they are highly correlated. Care should therefore be taken when comparing the mean health scores among studies that used proxies and those that did not. The possible mean difference between patient and proxy responses becomes more problematic if it is planned to intermingle the patient and proxy data within a single study as this may lead to biased results (Epstein et al 1989). Ideally the reliability of proxy-provided data should be examined by obtaining data from the patient as well as from the proxy with the patient's information being used as the standard. This approach



uses the assumption that the patient's assessment of his or her own health status is the gold standard to which all other assessments should conform (Rubenstein et al 1984). This was done in the EHFS and the results are presented in section 4.3. However, patients may not always report their health accurately which may therefore limit the usefulness of the test-retest approach. For example, patients may tend to overestimate their functional ability as they may be trying to simply conceal their disability so that they do not feel themselves to be a burden or they may be using denial as a psychological adaptive method to cope with their disability. Alternatively they may have a shifted time frame so that they perceive their current functional level as what it was before their illness. Another factor which may arise in a hospital setting, is that patients may overstate their level of functioning in the hope that they will be discharged sooner (Rubenstein et al 1984). Studies that use multiple interview protocols can nest a reliability study of patient and proxy responses within the main study.

This can make important contributions to the understanding of the study results as the impact of proxy related misclassification can be assessed and such a study was performed in the EHFS (Nelson et al 1990). The few studies that have been performed in this area that have been reported in the literature have been limited by their use of only severely ill patients or have restricted themselves to a limited range of health dimensions such as functional status (Rubenstein et al 1984).

When using proxy derived data it should also be borne in mind that the nature of the proxy respondent may influence his/her ability to provide information. For example, the patient's spouse or other relatives would be able to provide more information about adult life than would institutional staff. This was taken into account in the EHFS as a more restricted range of information was asked from proxies who looked after patients in an institutional setting. Other factors which affect the provision of information are: topic, degree of detail requested, race, age, sex, length of time for which the subject and the proxy lived together, or frequency of contacts if they lived apart (Kelsey et al 1985). Proxies with a close association with the patient tend to over-represent the level of the patient's impairment relative to the patient's own judgement and conversely the proxies with less contact with the patient tend to under-represent their impairment (Magaziner et al 1988, Epstein et al 1989, Rothman et al 1991). Furthermore proxies for patients not in institutional care may

underestimate patients functioning if they feel overburdened by the patient. It may be the result of an unconscious exaggeration of their caregiver role. However it may also be a conscious process in order to gain sympathy or to encourage the clinician to recommend nursing home placement for the dependent person they care for. An overprotective or uninterested proxy may simply be misinformed. Also the proxy's perception of the patient's helplessness may increase if the patient is hospitalised (Rubenstein 1984). The source of the proxy data was recorded in the EHFS and the possible biases associated with the different sources were borne in mind when the results for the proxy/patient validation study were interpreted.

## **2.6 HEALTH ASSESSMENT**

In this section the health domains considered briefly in section 2.2.1 will be expanded upon. Further detail will be given about what is encompassed in each health domain as well as specific methodological problems associated with their measurement and some of the scales used for this purpose. The specific research instruments chosen to assess each domain in the EHFS and the rationale behind their choice will be presented in section 3.5.1.

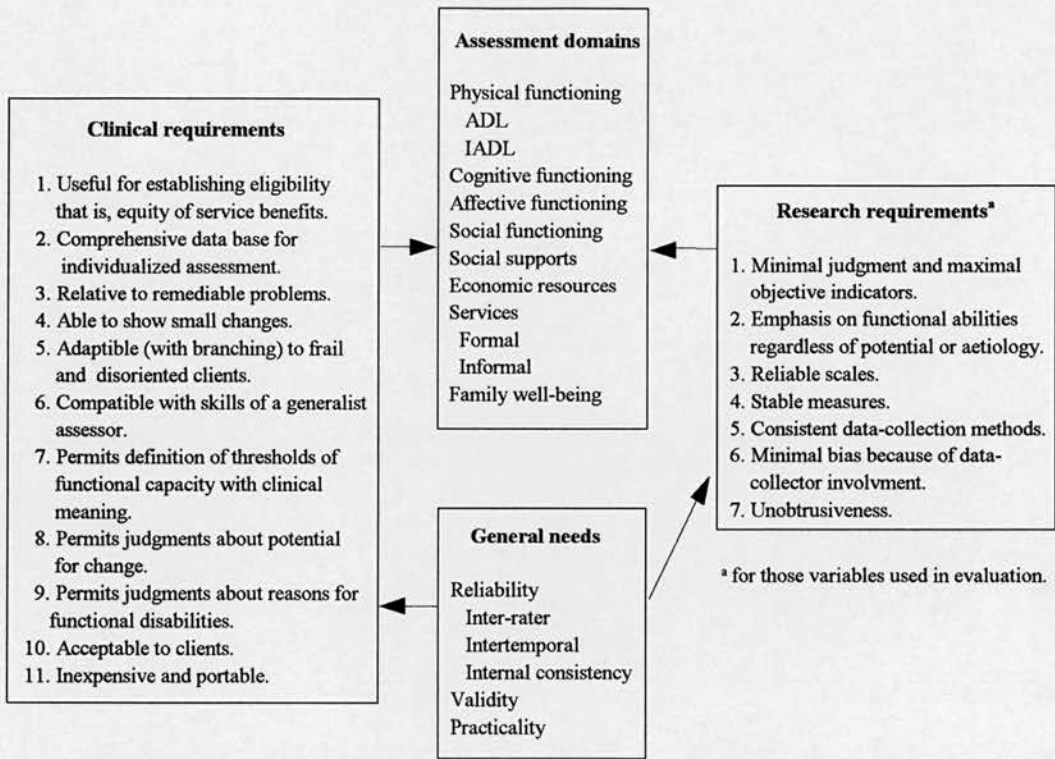
### **2.6.1 General Considerations**

In the elderly, the physical, mental, social, and economic aspects of wellbeing are even more closely interrelated than they are in younger people. Frail elderly persons often present with multiple problems which interact. Multidimensional assessment is therefore required. Comprehensive assessment cuts across disease categories, addressing physical, cognitive, emotional and social functioning (Applegate et al 1990). Rubenstein and Rubenstein (1991) summarise the purpose of geriatric assessment programmes as being

'multidimensional diagnostic evaluation; planning therapy; providing limited or more extensive treatment; arranging for rehabilitation; determining optimal placement; facilitating primary care resources; geriatric education and research.'

This definition reflects the greater emphasis on functional impairment rather than disease, and on the importance of the social environment for the elderly.

The distinction between instruments used for clinical use and for research purposes is a matter of emphasis and priority rather than clear cut differences. Kane and Kane (1981) succinctly summarised the requirements of clinical and research instruments to assess the health of elderly patients in Figure 2.4.



**Figure 2.4** Criteria for clinical and research health assessment scales (Kane and Kane (1981))

In selecting a specific research instrument the investigator must decide firstly on the purpose of the measurement in terms of the questions that need to be answered. This will determine the type of information that is to be collected, as well as the stringency of the data collection protocol, the amount of detail required and the approach to the analysis. The psychometric qualities of the instrument also need to be reviewed when assessing an instrument's suitability as discussed in section 2.4.4. The function of the measurement, that is whether it is to be used for screening, monitoring, or predictive purposes is also an important determinant in selecting the most appropriate research instrument. The nature of the target population and the capabilities of the potential users must also be taken into account (Jette 1980, Kane and Kane 1981, Applegate et al 1990).

The selection of assessment scales for the EHFS was very much based on the recommendations of the joint working party from the RCP and the BGS in 1992. The joint working party selected six health domains for assessment and it was largely guided by the WHO recommendations outlined in section 2.2.1. The domains selected were : activities of daily living; communication, visual and hearing disability; memory and cognitive function; depression; quality of life; and social status. For the EHFS three additional domains were included for assessment purposes and these were patient satisfaction, hip pain and hip function. Each of these domains will now be expanded upon in terms of what they cover, the methodological difficulties encountered in their measurement and the assessment scales that were considered for the EHFS.

### **2.6.2 Activities of Daily Living**

The activities of daily living (ADL) may be subdivided into primary ADL and instrumental ADL according to the nature of the activity. This section will start with a discussion of the more basic primary activities before moving on to the instrumental activities.

#### **2.6.2.1 Primary Activities of Daily Living**

The primary activities of daily living (PADL) are concerned with basic bodily maintenance. They cover walking, transferring, maintaining continence, dressing, feeding, communication and bathing (RCP and BGS 1992). Collectively they represent the single most important area of personal functioning. Ability to perform these activities is related to the patients physical and mental health and they may have a direct influence on social well-being (Fillenbaum 1984).

The PADL scales are used most widely to provide information on baseline function, screening and monitoring a patient's clinical course. The capacity to perform these activities can be used to help assess whether it is feasible for a person to live independently in the community with the provision of services or whether it is necessary for them to move to a specialised residential setting (Fillenbaum 1984). They are also used for setting goals for patients who have a high degree of impairment, especially in rehabilitative settings (Applegate et al 1990). Patients with higher level of disability, as gauged by their



PADL score, may require more time in hospital following a hip fracture, require more inputs and be more difficult to discharge. The PADL score may also be of use in clinical audit because of their potential role as a casemix adjustor (RCP and BGS 1992).

A critical definitional issue with the PADL scales concerns whether to count as disabled only persons 'receiving active human assistance' or whether to include persons who rely on 'special equipment or mechanical aids' and persons requiring only 'supervision or stand-by assistance'. A further methodological issue is whether to classify patients according to what they actually do or according to their potential capacity (Guralnik et al 1989). Most of the standard assessment tools do not evaluate mobility or characterise the use of important aids to mobility, such as a walking stick, zimmer or wheelchair. Furthermore, most do not indicate whether the patient can perform a given activity safely which is a very important issue in rehabilitative care.

The Barthel Index (Mahoney and Barthel 1965) was selected by the joint working party from the RCP and BGS in 1992 on the basis that it was : widely used; practical to administer; had undergone extensive psychometric testing; and correlated well with other outcome variables such as mortality and placement. Its ceiling effect was noted and it was recommended that a scale which assessed the instrumental activities should be administered to patients who scored highly on the scale to minimise this problem. Further detail about the PADL scales considered for the EHFS may be found in Appendix 3 and are summarised in Appendix 4.

#### **2.6.2.2 Instrumental Activities of Daily Living**

The instrumental activities of daily living (IADL) are activities such as cooking, cleaning and shopping, and can be used to assess higher levels of performance than the PADL.

In general IADL scales possess several limitations not possessed by PADL scales. These include the lack of ability to scale the activities in a hierarchial manner according to the ease of performance, that is a lack of Guttman scalability; a greater sensitivity of the score to variations in mood and emotional health; a greater difficulty in measuring IADLs in an

institutional setting; and an overemphasis on traditional women's tasks such as cooking, cleaning and laundering (Kane and Kane 1981). There may also be a cultural bias with IADL scales as some items may scarcely be relevant and performance of others may require a different level of capacity in different settings (Fillenbaum 1984).

The IADL scales considered for the EHFS are presented in Appendix 3 and are summarised in Appendix 4.

### **2.6.3 Communication, Visual and Hearing Disability**

The assessment of communication, visual and hearing disabilities is of great importance in the elderly as they are not uncommon and may have a considerable influence on their level of functioning. The predictive value of all other assessments is also probably improved if these three areas are taken into account (Ware 1987).

The RCP and BGS (1992) recommended that specific questions from the Lambeth Disability Screening Questionnaire be used (Peach et al 1980). These questions were :

Do you have difficulty :

- i) seeing newsprint even with glasses?
- ii) recognising people across the road even with glasses?
- iii) hearing a conversation even with a hearing aid?
- iv) in speaking?

However it was recognised by the joint working party that the psychometric properties of these questions were not known and that they should be researched.

### **2.6.4 Memory and Cognitive Function**

Memory and cognition is particularly important in the elderly given that abnormal cognition due to a dementia syndrome or delirium is not uncommon in this age group. In the EHFS 34% of the patients had impaired cognition as gauged by the Abbreviated Mental Test shortly after their hip fracture. As a result of this the definition and methodological difficulties encountered in the investigation of dementia and delirium will be presented in some detail.

Clinically it is important to identify dementia and delirium as efforts should be directed at determining their cause. They are also potentially important as casemix indicators as patients with dementia are more difficult to rehabilitate and patients with delirium consume more resources than comparable patients without impaired cognition (RCP and BGS 1992).

The term dementia is a generic one covering numerous conditions that have certain clinical features in common. The diagnosis is made on clinical grounds. In a dementing illness there is the impairment of several aspects of cognition at the same time, or 'global intellectual impairment'. This occurs in the presence of a clear consciousness and this feature differentiates the condition from a confusional state. The diagnostic criterion for dementia are : a loss of intellectual abilities sufficiently severe to interfere with social or occupational functioning; memory impairment; and at least one of - impairment of abstract thinking, impaired judgement, other disturbances of higher cortical function such as aphasia, and personality change; state of consciousness not clouded (American Psychiatric Association 1980).

The dementia syndrome occurs in Alzheimer's disease, in cerebrovascular disease, and in other conditions primarily or secondarily affecting the brain. Alzheimer's disease is a primary degenerative cerebral disease of unknown aetiology with characteristic neuropathological and neurochemical features, and a post-mortem is required for a definitive diagnosis. It is the single largest cause of dementia. In this disease there is initially a failing memory and spatial disorientation. The patient's personality then begins to disintegrate and focal brain signs may start to appear such as the inability to perform mathematical calculations. The final stage is typified by the patient being apathetic and wasted, bedridden and incontinent. Alternatively they may be ceaselessly active (Collier and Longmore 1987). These three stages have been labelled as representing mild, moderate and severe dementia respectively.

In assessing the presence or absence of dementia it is necessary to take special care to avoid false-positive identification. Motivational or emotional factors, particularly



depression, in an elderly person in addition to motor slowness and general physical frailty may account for their failure to perform satisfactorily on a cognitive test rather than because of a loss of intellectual capacity. When the dementia is mild, the patient is aware of his or her deficits, and this may create both anxiety and depression (Scully 1985). Depression is therefore common in patients with dementia. It must also be remembered that many elderly patients with mild-to-moderate cognitive impairment often maintain their social skills, in terms of superficial interactions, and clinically important impairment may remain undetected (Perez and Silverman 1984, McCartney and Palmateer 1985, Applegate et al 1990).

The reported prevalence of dementia in populations is very much dependent upon the operational definition used. Jorm et al (1987) reviewed the literature over the period 1945 to 1985 and concluded that the prevalence rates of dementia rose exponentially after the age of 60. A doubling of the prevalence rate of dementia was noted for every 5 year increase in age after the age of 60 years. Katzman (1986) reported a prevalence of severe dementia as being less than 1% in people aged 65-70 years rising to over 15% by the age of 85.

If the patient's consciousness is impaired then the clinical condition is called a confusional or delirious state. Diagnostic criterion are : clouding of consciousness; at least two of the following - perceptual disturbance, speech that is at times incoherent, disturbance of the sleep-wakefulness cycle, increased or decreased psychomotor activity; disorientation and memory impairment; clinical features that develop over a short period of time (usually hours to days) and tend to fluctuate over the course of the day; evidence from the history, physical examination, or laboratory tests, of a specific organic factor judged to be aetiologically related to the disturbance. It is an aetiologically non-specific syndrome and may be superimposed on, or progress into dementia (WHO 1990). It may occur at any age but is more common after the age of 60.

The instruments available to assess cognitive status do not identify or quantitate minimal but important loss and most are not sensitive to clinically important change because they

have threshold effects. Many people with slight impairments have scores in the normal range, whereas people with severe dementia may have no correct responses (Applegate et al 1990). This limits the use of these scales in clinical practice. Furthermore many instruments, such as the Abbreviated Mental Test (AMT) for example, do not measure the full range of mental ability, and care should be taken not to make a diagnosis on the basis of their result, nor are they able to suggest a specific aetiology (Rubenstein et al 1988). It should be noted that the process of clinical diagnosis incorporates a large amount of information beyond the patients self-report and their immediate behaviour and this additional information is often essential for correct diagnosis. They are however efficient screening instruments but the scores may be influenced by a number of factors such as educational level or hearing, visual and speech impediments. Patients may also do poorly on these tests if they are depressed, or have catastrophic reactions, or just feel overwhelmed. For example a patient with mild, sub-clinical Alzheimer's disease may have a sharp deterioration in his/her cognitive function after a hip fracture, but may return to his/her baseline level of functioning as the pain settles post-operatively. The role of the interviewer is also important in interpreting the actual scores obtained in memory and cognitive function tests. An interviewer who is more experienced in interviewing elderly patients and who is slower and more gentle may obtain higher scores than someone who is less empathetic for example.

The AMT was recommended by the RCP and BGS joint working party in 1992 to screen for memory and cognitive impairment in elderly hospitalised patients because it was the most widely used in Britain and because there was little to choose between it and some of the other scales. The other possible contending scales that were reviewed for the EHFS are presented in Appendix 3 and are summarised in Appendix 4.

### **2.6.5 Depression**

The prevalence of major depression in community-residing individuals has been reported to be around 5% (Weissman and Myers 1978, Blazer et al 1987) but in hospitalised hip fracture patients and other elderly surgical patients a prevalence of 30% has been noted as was the case in the present study (Billig et al 1986, Applegate et al 1990, Magaziner et al

1990). It is an important diagnosis to make because it is amenable to treatment and because if untreated it may interfere with the patient's subsequent rehabilitation (RCP and BGS 1992). It should be noted that as with dementia the prevalence of depression is very much determined by the methodology used to ascertain it.

Symptoms suggestive of depression include low mood, loss of interest and enjoyment, and reduction of energy leading to increased fatigability and diminished activity. Other common symptoms are: impaired concentration and attention; reduced self esteem and self confidence; ideas of guilt and unworthiness; bleak and pessimistic views of the future; ideas of self-harm or suicide; disturbed sleep; and diminished appetite. The presence of dementia does not rule out the diagnosis of a treatable depressive episode, but communication difficulties are likely to make it necessary to rely more than usual for the diagnosis upon objectively observed somatic symptoms, such as psychomotor retardation.

Version 10 of the International Classification of Diseases grades the severity of depression into mild, moderate and severe, the latter being subdivided into two groups depending on the presence or absence of psychotic symptoms (WHO 1990).

Most of the scales are valid, reliable and useful for screening and provide a quantitative assessment of the effects of therapy (Applegate et al 1990). As the symptoms of depression are not unique and occur in other psychiatric disorders any depression rating scale is not specific and should not be used for diagnostic purposes. It should also be noted that although some scales, such as the Geriatric Depression Scale, provide cut-off points intended to help establish a clinical diagnosis of depression, the validity of these instruments in making a diagnosis is not sufficiently high to warrant basing the final diagnosis on their results alone (Applegate 1987).

Most of the questionnaires have a number of questions about somatic symptoms, such as fatigue and pain for example, and consequently they have difficulty differentiating the effects of physical illness from those of depression especially amongst the more elderly. Also because many of the questionnaires depend on information obtained in interviews, their usefulness may be limited in patients who have severe cognitive impairment or who

are uncooperative. The Geriatric Depression Scale for example has not been shown to be valid in patients with dementia (Burke et al 1989).

The RCP and BGS joint working party recommended in 1992 that the short form of the Geriatric Depression Scale (Yesavage et al 1983) be used for the assessment of depression in the elderly on the basis that it was short and avoided somatic symptoms which are common amongst the elderly and consequently of less predictive use. It was recognised that further psychometric testing was required. This scale as well as the other contenders considered for the EHFS are given in Appendix 3 and are summarised in Appendix 4.

### **2.6.6 Quality of Life**

There is no universally accepted definition of quality of life (QoL) which severely limits clinical research in this area. It is a collective term summarising a set of related interacting dimensions and attempts at establishing boundaries around the term have proved difficult (Aaronson 1990). It has been described by Campbell and colleagues (1976) as being

'a vague and ethereal entity, something that many people talk about, but which nobody very clearly know what to do about.'

It is generally accepted however that QoL must be addressed at a multidimensional level and that it must have both objective and subjective components. The objective parameters include functional capacity as well as physical, mental and social status of the individual. The subjective elements include morale, life satisfaction and self-esteem (RCP and BGS 1992). In its broadest sense, quality of life (QoL) encompasses all aspects of human life: material and physical components, social, emotional and spiritual wellbeing (Fletcher et al 1992).

A large obstacle to the development of quality of life (QoL) research has been to do with the difficulty of co-ordinating the social and medical sciences in a clinical setting. Biomedical and social science researchers belong to two quite distinct professional cultures with their own research techniques. The primary reliance on subjective data without there being a gold standard makes many medical researchers sceptical of the scientific soundness of the methodologies employed in the social sciences. It is often

assumed that subjectively derived data do not meet rigorous standards of validity and reliability, which is not necessarily the case. The problem is further compounded by the fact that the terminology and statistical tests are not identical in the two fields of research thereby making the interpretation of the other professions research more difficult. Additionally the practical considerations of carrying out psychosocial research in a clinical setting is often not well understood by the social scientists, such as the fact that instruments need to be brief and simple to use in a range of settings, and this hampers the introduction of QoL tools into clinical research (Katz 1987, Aaronson 1990). Studies reviewing the use of QoL tools in clinical settings have reported very low levels of usage. O'Young and McPeck in 1987, for example, reported that only 3% of surgical trials had systematically evaluated QoL items.

Quality of life is a complex attribute like intelligence for which there is similarly no gold standard. The choice of intelligence test for any clinical or research situation is very much based on the particular circumstances and this is also the case for QoL measures (Bergner 1989). No single method for evaluating the QoL exists that will suit all circumstances because of its multi-dimensional nature. Investigators must therefore make it clear which elements of QoL they propose to evaluate and be able to justify their choice of methods (Fletcher et al 1992). Some of the scales only consider subjective well-being whilst others consider multiple dimensions of health (RCP and BGS 1992).

The level at which cognitive impairment precludes the patient from providing valid information about their QoL is not known. Further research is required to examine this issue and to evaluate the capacity of relatives or other groups to represent the views of such patients (Uhlmann et al 1988). At present there is some evidence to suggest that there is a poor correlation between professional and patient perceptions of QoL (Neugarten et al 1961, Pearlman and Jonsen 1985, Slevin et al 1988, Sprangers and Aaronson 1992). There are also uncertainties about the advantages of different administration strategies (Bergner 1989). Another methodological problem which has arisen with the use of QoL tools in clinical practice is that they suffer from a ceiling effect and although they have been demonstrated to be responsive to major medical interventions



their responsiveness to less significant events has not yet been shown. The measurement of QoL of institutionalised elderly patients also requires further consideration (Fletcher et al 1992).

In 1992 the joint working party from the RCP and BGS suggested that the Philadelphia Geriatric Center Morale Scale (Lawton 1975) should be used to assess the QoL in elderly hospitalised patients. This scale assesses subjective well-being only. It was selected on the basis that it considers the present and has been shown to be responsive to health care interventions (Rubenstein et al 1984). It may also have a predictive role for future depression (Morris et al 1975). The QoL scales considered for the EHFS are reviewed in Appendix 3 and summarised in Appendix 4.

#### **2.6.7 Social Status**

The recognition of social determinants of health extends the concept of health to beyond the individual and it is a complex area to address (Ware et al 1981). The physical and mental aspects of well-being are more closely interrelated with social and economic aspects for the elderly than they are for younger people and may also determine the impact of disease and the need for health care (RCP and BGS 1992).

The term social status encompasses a number of related concepts including social support and economic and environmental resources. The relative importance of each of these components to social status as an entity is not known. Social support is recognised to have an important independent influence on health in terms of morbidity and mortality and the evidence for this is authoritatively reviewed by House et al (1988). The term social support is used to refer to all social relationships that an individual has and their effects (Sainsbury 1991). Four broad classes of supportive acts or behaviours have been identified by House and these are : emotional; instrumental such as performing a household repair for example; informational where advice, suggestions or directives do not solve a problem in itself but can be used by the recipient to help him/herself cope; and appraisal where information is transmitted in the form of affirmation or feedback which is relevant to self-evaluation or social comparison by the recipient. Assessment of social

support requires consideration of the number of relationships an individual has with relatives, friends, neighbours, religious and other organisations as well as the frequency and quality of contact with those individuals and organisations (Seeman et al 1987, Hanson et al 1989, Blaxter 1990). The link between social support and health may be through psychological and biological mechanisms and further investigation is required to elucidate these factors more clearly (House et al 1988). For example sympathetic adrenomedullary responses and hormonally mediated adrenocortical responses may be involved (Berkman 1985). Economic and environmental factors such as income, wealth and housing for example have also all been shown to affect health (RCP and BGS 1992).

The assessment of social determinants of health is not straightforward and no single instrument exists to do this, but if it did, it would probably be very lengthy. On this basis the joint working party from the RCP and BGS in 1992 suggested that the following six areas should be addressed using a checklist in an elderly population : living alone; difficulties in managing personal care; difficulties in managing the environment; perceptions of financial need; need of carers; and gaps in services. Any problems identified would then be subject to a more detailed enquiry. It was recognised that the use and value of such an approach was not known and that the questions would require regular review when circumstances such as benefits and taxes, for example, changed.

#### **2.6.8 Patient Satisfaction**

Patient satisfaction is growing in importance and achieving a higher profile in research (Carr-Hill 1992). One of the main reasons for this is the emphasis that is now being placed on consumer sovereignty in the National Health Service. This means that health care provision is now expected to be shaped by patients' demands and preferences and patient satisfaction will be considered to be an outcome of the health care process. Additionally evidence is also beginning to emerge that satisfaction is related to improvements in health status as well as to whether a person seeks medical advice, complies with treatment or maintains a continuing relationship with a medical practitioner (Larsen and Rootman 1976, Fitzpatrick et al 1983, 1987, 1991).



Patient satisfaction is a concept that has a common-sense meaning which has rarely been subject to critical scrutiny. It is sometimes treated as an attitude or set of attitudes but it is more usefully thought of as an evaluation or set of evaluations by the patient. The number of dimensions that are distinguished by patients is not universally agreed. In 1991 Fitzpatrick defined the following 11 domains : humaneness, informativeness, overall quality, competence, bureaucracy, access, cost, facilities, outcome, continuity, and attention to psychosocial problems. This list appears to be broadly comprehensive and in keeping with what is used in other studies. It should be noted that the cost dimension is not usually included in British studies on patient satisfaction. As satisfaction is a derived concept that is related to a number of factors such as lifestyle, past experiences, future expectations and the values of both the individual and society it is likely that it will be defined very differently by different people and by the same person at different times. This interpersonal and over-time variability casts doubt on the value of attempting to define a unitary concept of satisfaction. In addition patients' expectations will vary according to the presumed success of the intervention and to their experience of medical care (Carr-Hill 1992).

The validity of patient satisfaction questionnaires is difficult to establish as there is no gold standard to use as a criterion. Construct validity has however been demonstrated in a few studies. For example, three studies have found a positive relationship between patient attitudes toward some component of hospital care and their impressions of improvement in health (Rubin 1990, Fitzpatrick 1991). Several studies have shown that patients are able to discriminate between different features of care but are limited in their usefulness because the patient ratings have not been compared to independent ratings of these same features such as reports from hospital staff (Rubin 1990).

The reliability of patient satisfaction surveys are frequently questioned. Few studies have reported their test-retest reliability. A slightly larger number have reported their results on internal consistency and the majority of these are satisfactory. Only a few studies have examined inter-rater reliability (Baker 1990, Rubin 1990, Fitzpatrick 1991).

Other methodological issues need to be addressed with patient satisfaction studies. Few studies have addressed whether different survey methods such as different modes of administration or timing are equally feasible, reliable or valid. Nor has the problem of possible bias arising from non-responders been fully addressed (Rubin 1990).

A major problem with patient satisfaction questionnaires is the lack of variability in responses as over 80% of respondents express satisfaction for any given item. This results from the fact that many patients in the NHS are reluctant to express critical comments about their health care. Another reservation about the use of satisfaction surveys is the competency of individuals to make sensible judgements about the health care that they receive because of its technical complexity. Also the health professionals may view the factors that the patients use to make their judgements as potentially misleading. Furthermore the characteristics of the patient or the reason for their hospitalisation may affect the responses more than significant aspects of the provision of health care (Fitzpatrick 1991).

Demographic and social factors have been shown to influence patient satisfaction but not in a consistent manner (Fleming 1981, Matthews et al 1987). On balance younger patients tend to report more dissatisfaction than older patients and men do so more than women. Middle class and more educated patients may also express more dissatisfaction (Fleming 1981, Inguanzo and Harju 1985). These differences may arise in part from a difference in readiness to express negative comments in response to questionnaires as well as a more fundamental difference in the expectations of health care.

It is not possible to recommend a 'standard' patient satisfaction survey as the objectives and the context in which they are to be applied vary widely (Carr-Hill 1992). Reviewing the literature the Patient Judgements of Hospital Quality (PJHQ) questionnaire was noted to have undergone extensive psychometric testing and had a high face validity for the EHFS as it covered a broad range of management issues (Rubin et al 1990). The properties of this instrument are presented in Appendix 3 and summarised in Appendix 4.

### **2.6.9 Hip Function**

Most research looking at hip function has been undertaken in order to evaluate the results of total hip replacements. Although a number of assessment scales have been used for this purpose since the 1950's their usefulness has been questioned because of their lack of uniformity and objectivity. All include the clinical parameters of pain, walking ability, function and mobility but the relative weight given to each varied (Merle d'Aubigne and Postel 1954, Larson 1963, Harris 1969, Wilson et al 1972, Kavanagh and Fitzgerald 1985). The numerical ratings were very much dependent on the subjective values of the authors of the scales. The reported numbers were not necessarily based on quantifiable variables, nor did they always reflect clinical outcome accurately. Despite this the overall ratings of hip function reported by patients using different rating scales were not significantly different (Callaghan et al 1990). None of the hip assessment scales published prior to 1990 have undergone any psychometric testing.

The need for a more systematic method for reporting the results of total hip replacements using a scale that has undergone rigorous psychometric testing has become increasingly recognised by orthopaedic surgeons. Johansen and colleagues published their Hip Rating questionnaire in 1990 to provide the basis for a standard terminology and the results of the psychometric testing of their questionnaire were reported in 1992. The clinical parameters incorporated were descriptions of pain, levels of work and activity, walking capacity, satisfaction of the patient, and results of physical examination. Criteria for radiographic evaluation of the replacements was also included. Convergent validity was established for the different domains covered by the hip-rating scale. Test-retest reliability was reported to be good and the internal consistency was also reviewed. The responsiveness of the questionnaire was stated to be excellent. The hip-rating questionnaire has made an important contribution to the standardisation and evaluation of hip function in a more valid and reliable manner.

At the time the EHFS was being designed the Hip Rating questionnaire (Johanson et al 1992) had not been psychometrically tested and the Harris Scale was selected to assess hip function as it was the most widely used of the available scales. Limitations of its use were

recognised and these are outlined in section 3.5.2. The properties of the Harris Scale are presented in Appendix 3 and summarised in Appendix 4.

### **2.6.10 Hip Pain**

Hip pain is self-evidently an important outcome measure following a hip fracture but no instrument has been reported in the orthopaedic literature which has been specifically designed to assess hip pain. All of the published scales designed to assess hip function do however have hip pain as a key component. None of these scales, except the Hip Rating Questionnaire, have undergone psychometric testing as mentioned in the previous section.

The few epidemiological studies that have reported hip pain following a hip fracture have simply used a question with an ordered categorical response.

## **2.7 SUMMARY**

It was the purpose of this chapter to give an overview of health with special reference to the health of the elderly. Six domains of health were identified by a joint working party from the Royal College of Physicians and the British Geriatrics Society in 1992 for the assessment of the health of the hospitalised elderly and these formed the framework for the discussion. The six domains were : activities of daily living; communication, vision and hearing; memory and cognitive function; depression; quality of life; and social status. Patient satisfaction, hip function and hip pain were additionally included for the Edinburgh Hip Fracture Study. An outline of what each health domain encompassed was given along with a discussion about specific methodological difficulties encountered in its measurement and the scales considered. Background information on assessment scales was also given. This covered the rationale for their use, their areas of application, their advantages and disadvantages as well as their properties. Methodological problems encountered in assessing the health of the elderly were also reviewed with emphasis on the problems of obtaining informed consent, collecting the data as well as the most appropriate source of the data.

## **CHAPTER 3**

### **STUDY METHODOLOGY**

#### **3.1 INTRODUCTION**

The purpose of this chapter is to discuss the methodological issues involved with the setting up of the Edinburgh Hip Fracture Study. It will begin with a discussion on sample size followed by the eligibility criteria. The procedures for patient identification and selection will then be covered before moving on to the data collected and how this was done. Details on the study organisation, including the time scale and the pilot study, are dealt with in the section on study administration. The chapter is concluded by a review of the statistical methods employed in the EHFS.

#### **3.2 SAMPLE SIZE CALCULATION**

Consideration of the calculation of the sample size required for the study began with a review of the annual figures for hip fracture admissions to hospital in Lothian (Information and Statistics Division 1990). In 1988 there were 915 hip fracture admissions and this was reasonably consistent with the number in previous years. As Edinburgh accounts for approximately 55% of the population in Lothian then around 250 patients would reasonably be expected in a six month recruitment period.

A six month recruitment period was viewed as being optimal for logistical reasons as it would permit the recruitment phase to be completed before the six month interviews had begun. This was considered to be important because the six month interviews were anticipated to be quite time consuming and would not have permitted additional recruitment to take place simultaneously. By six months post-fracture most of the patients were expected to have returned to their usual place of residence and this would have meant a considerable amount of travelling. Additionally the increased social commitments of patients at this stage would have made them less flexible regarding possible interview times.



If an attrition rate of 20% was allowed for, to account for patients being ineligible for the study, or refusing to participate, then a six month recruitment phase would be expected to yield a starting population of 200 patients. Review of the literature suggested that a mortality rate of around 20% could reasonably be expected for the study population over the one year period of follow-up (Jensen 1984, White et al 1987, Elmerson et al 1988, Magaziner et al 1989). Consequently it was anticipated that complete follow-up on 160 patients could be expected for the study.

There is no straightforward way of relating sample size to the power of detecting multivariate relationships. However, as an indication, a sample size of 160 will have a 90% power to detect a statistically significant association between two variables if their population correlation coefficient is 0.25.

These calculations suggested that an initial cohort of around 250 patients would be sufficiently large to detect relationships between pre- and post-fracture variables of prognostic significance.

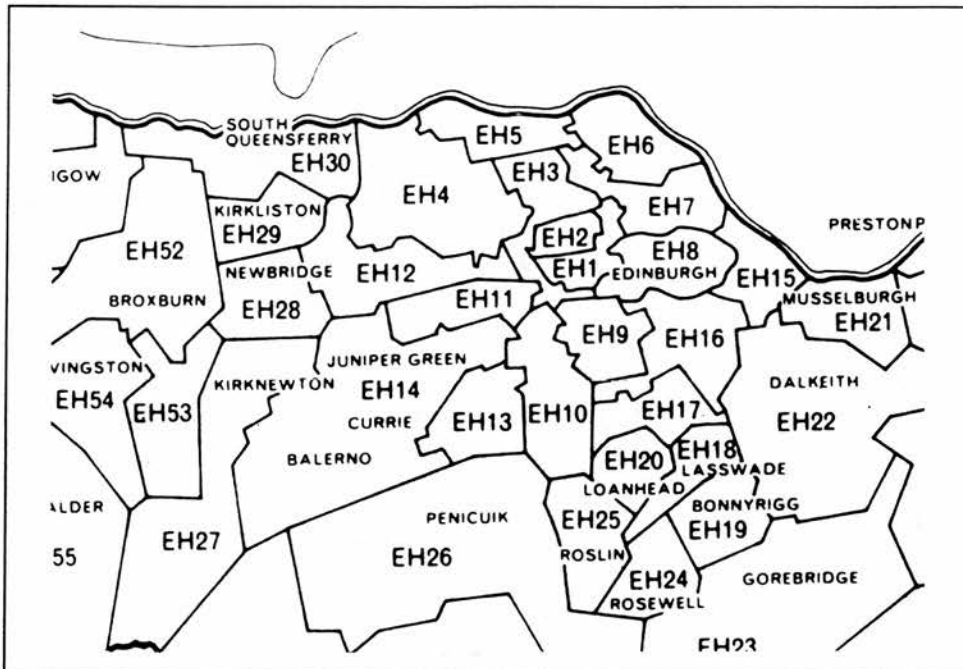
### **3.3 STUDY ELIGIBILITY**

Overall the policy of the study recruitment was to be as unselective as possible in a population-based study looking at the prognostic factors for outcome in individuals with a probable osteoporotic hip fracture. To date most of the researchers in this area have restricted themselves to a particular group of individuals, such as people resident in the community, and/or have restricted the range of variables that they have looked at for deriving prognostic indices. To gain a comprehensive picture of the full burden of a hip fracture at both the individual and population level requires an approach that is broadly based and follows up patients for a sufficient length of time.

Patients were deemed eligible for the study if they were sixty years or over at the time of their fracture and their usual place of residence was in Edinburgh. For pragmatic reasons the geographical boundary for the City of Edinburgh was defined as 'the area encompassed by those postcode areas which have at least 25% of their own area within the boundaries



of the City of Edinburgh District, and within a ten kilometre radius of the Royal Infirmary of Edinburgh'. The study working definition comprised postcode areas EH1 to EH17 inclusive. See Figure 3.1.



**Figure 3.1** Geographical area for study recruitment (Post Office (1991))

Within this cohort patients were excluded for the following reasons :

- i) A fracture due to a metastatic deposit or some other underlying problem with the upper end of the patient's femur such as a history of a traumatic injury requiring an arthrodesis.
- ii) A fracture sustained as a result of a high velocity road traffic accident.
- iii) The presence of a medical condition that would interfere with the assessment of the outcome of the hip fracture. An example of this would be a recent cerebrovascular accident which may have a profound disabling effect on the patient and is subject to a variable recovery. The effect of the hip fracture on the patient's life may then be very difficult to distinguish from that of the stroke.
- iv) The patient was obviously moribund at the time of admission or died within seven days of being admitted to hospital for the management of their hip fracture.

The rationale behind these criteria was to obtain a study population whose hip fracture was likely to be due to osteoporosis although empirical confirmation of this was not

sought for logistical reasons. The presumed common aetiological factor of osteoporosis is important for prognostic purposes. Additionally, it was also important to try to eliminate the excess noise created by the presence of medical conditions which would interfere with the assessment of the impact of the hip fracture. Patients were also excluded if they were obviously moribund at the time of their admission as it would have been unethical to have enrolled them into the study. Furthermore follow-up information would not have been available on them as would be the case with patients who died within a week of their admission.

Patients who suffered an event during the course of their follow-up which was a direct consequence of the hip fracture itself, such as a deep hip infection, were retained in the follow-up analysis. Other patients who experienced a complication which was probably related to the hip fracture and its management, such as a perioperative myocardial infarct, were similarly included in the follow-up analysis. However, patients who developed a medical condition that was not related to the hip fracture, or its management, and which profoundly interfered with functional recovery from the hip fracture were excluded from all of the follow-up analyses apart from survival. The presence of such a medical condition, such as a cerebrovascular accident, would confound the assessment of the impact of the hip fracture.

It was further necessary to subdivide the patients who were eligible for the study into those who were able to provide their own information, the self-reporting group (SRG), and those who required an informant, the informant requiring group (IRG). The vast majority of the latter group required someone who knew them well to provide information on their behalf because of the poor quality of their recall due to the presence of dementia. The person supplying this information was called a proxy. If the patient was living at home then this person was usually their main carer. In an institutional setting the proxy recruited was usually a member of the residential care or nursing staff. Every effort was made to use the same proxy at subsequent interviews to minimise inter-observer differences. A review of the literature suggested that around 20% of the patients that would be recruited for the study would require a proxy because of dementia. However this figure was quite

variable as the prevalence of dementia is very much influenced by how dementia is defined as well as the intensity of the case finding (O'Connor et al 1989, Colsher and Wallace 1991, Heeren et al 1991, Barberger-Gateau et al 1992). In addition it was anticipated that a small group of patients would require a proxy because of their inability to communicate satisfactorily for reasons other than dementia such as the presence of an expressive dysphasia for example. In practice 39% of the patients in EHFS required an informant of whom 96% had dementia.

As data from informants was being used as well as data from patients themselves in the EHFS it was necessary to ascertain whether the two sources of information yielded comparable information as previously discussed in section 2.5.3. A nested validation study was conducted as part of the EHFS to address this issue. Further detail is given in section 3.5.4 and the results of the proxy/patient study are given in 4.3.

### **3.4 STUDY PROCEDURES**

#### **3.4.1 Patient Identification**

It is now standard orthopaedic practice to operate on all patients with a fractured hip unless there are extreme extenuating circumstances such as the patient being obviously moribund at the time of their fracture. Consequently hospital admissions reflect fairly accurately the hip fractures that have occurred.

The closure of the acute orthopaedic service in August 1991 at the Western General Hospital meant that nearly all of the hip fractures sustained by individuals living in postcode areas EH1 to EH17 inclusively were managed at the Royal Infirmary of Edinburgh (RIE). The only other hospital within the boundary of the City of Edinburgh which manages acute hip fractures is the Murrayfield Hospital but the numbers involved only amount to a few in any given year. Over the six month study recruitment phase there were no patients admitted to this hospital for the definitive management of their hip fracture who resided in the defined geographical area for study recruitment. It was also possible that a small number of patients may be treated at St. John's Hospital at Howden, in West Lothian, if they sustained a fracture whilst in the area. Weekly contact with the

orthopaedic ward and a subsequent computer search by the medical records staff at St. John's Hospital revealed that no patients were admitted with a hip fracture who lived in the Edinburgh postcode areas EH1 to EH17 inclusive during the study recruitment phase.

Information on cross-boundary flow provided by the Information and Statistics Division of the Scottish Health Service indicated that three patients who were normally resident in postcode areas EH1 to EH17 inclusively had their hip fracture managed in a hospital in a health board outside of Lothian.

Patients admitted to the RIE with a hip fracture after being assessed in the accident and emergency department are transferred to the admissions ward, also known as ward 2, of the orthopaedic unit. All admissions are recorded in the ward's admission book. Patients for the study were detected by reviewing this book on every alternate day. If there was pressure on bed space in ward 2 the patients would occasionally be admitted directly from the accident and emergency department to one of the other four orthopaedic wards. This was also more likely to occur if the admission was a transfer from another ward in the RIE or from another hospital. The vast majority of cases did however pass through ward 2 pre-operatively and then were moved to one of the other wards after surgery. If the patient required special care post-operatively then they were admitted to the high dependency unit in ward 9. It was therefore important to review the ward books in all of the orthopaedic wards every second day to ensure that no hip fracture patients were overlooked. Regular liaising with the ward staff also proved to be beneficial in yielding a few cases where the patients were either inadvertently not recorded in the ward admission book or had an incorrect diagnosis entered. There were also a few instances where a patient had not had an obvious fracture on admission but isotopic scanning of their painful hip had subsequently revealed a fracture. Speaking with the ward staff, reviewing the patient's medical notes as well as reviewing the daily operating lists helped maximise the study's overall ascertainment of hip fracture cases.

### **3.4.2 Patient Selection**

The initial step after identifying possible study participants, as outlined in the section above, was to review their medical records to confirm their age and their usual place of residence. If they were sixty years of age or older and lived in Edinburgh postcode areas EH1 to EH17 inclusively then their medical records were closely reviewed to determine whether they fulfilled the criteria to be eligible for the study. If anything needed further clarification at this stage, such as the medical condition of the patient, then the appropriate information was sought. If the patient was not eligible then a limited amount of information was obtained, from either the patient themselves or from someone else who knew them well if they had a communication difficulty, as detailed on form IIc. Refer to Appendix 5. In some cases, such as moribund patients who died shortly after admission, the possible distress caused to a spouse by further information collection was clearly not desirable and so the limited information from the medical records was made to suffice.

After establishing that the patient was eligible for the study the medical notes often indicated whether the patient would be able to provide all of their own information or whether a carer would have to do so. Any patient who died within seven days of admission or who were obviously moribund at that stage were classified as being ineligible for the study, as described in section 3.3.

## **3.5 DATA COLLECTION**

### **3.5.1 Selection of Research Instruments and ad hoc Questions**

At the time when the study was being designed the joint working party from the RCP and BGS were in the process of selecting standardised health status assessment scales for use in the elderly. The scales that were recommended and the domains that they cover are as follows :

- i) Barthel Index - Primary activities of daily living
- ii) Abbreviated Mental Test Score - Memory and cognition
- iii) Geriatric Depression Scale - Depression
- iv) Philadelphia Geriatric Morale Scale - Quality of life



v) Lambeth Disability Screening Questionnaire - Communication, visual and hearing disability

To assess social status a short checklist of questions was suggested with more detailed review taking place as required.

Further detail about the health domains and the scales used to assess them was given in section 2.6.

Given that the scales recommended by the RCP and BGS were likely to become widespread in their use with the recent changes in the NHS, such as the introduction of annual assessments at the primary care level for people over the age of 75 as well as the emphasis on medical audit for example, it was decided that the study results would be of most use if the same research instruments were adopted. The only scale not employed was the Lambeth Disability Screening Questionnaire as more detailed information was necessary in the hip fracture population.

The contending scales considered for the EHFS are summarised in Appendix 3 and their main properties are summarised in Appendix 4. An independent review of the scales for the domains recommended by the RCP and BGS would have yielded the same selection for the EHFS as were chosen by the RCP and BGS.

An IADL scale was also included in the EHFS because it would provide further information about the impact of the hip fracture on the patient's lifestyle and hence the handicap experienced by the patient. It would also help overcome the marked ceiling effect known to exist with the Barthel Index. The Clackmannan Scale was selected for this purpose largely because it had been specifically designed for use in the elderly who have found it to be acceptable (Fernando 1977, Bond and Carstairs 1982). It had also undergone considerable developmental work and experience with its use has been gained in Scotland. Its mobility and self-care domains were used to provide comparative information with the other ADL scales used in the study. The other main scale considered to provide information on IADL was the OARS Multidimensional Functional Assessment Questionnaire (Fillenbaum 1978). The author specifically recommended however that



subsections of the scale should not be used independently as further research is required to establish the usefulness of the subsections as independent instruments. This questionnaire has 120 questions, of which only seven deal with IADL, and it takes 30 minutes to administer.

It was necessary to include a hip function assessment scale in the EHFS for obvious reasons. The Harris Scale was selected because it is the most widely used instrument for evaluating hip function in orthopaedic research. A further consideration was the fact that it was being employed in another hip study being conducted in Edinburgh at the time of piloting the current study so the opportunity for obtaining experience with its use existed. However limitations of the Harris Scale were recognised from the outset. It was originally described on a series of young patients who had sustained a traumatic dislocation of their hip and these patients can be assumed to have had normal hip function prior to their fracture. Many hip fracture patients in contrast have considerable limitation in their hip function prior to their fracture and consequently it is unrealistic to expect full restoration of function following their fracture. To illustrate this, if a patient was walking with a zimmer prior to their fracture and managed to regain this level of mobility after the fracture, and they had no hip pain, then this clearly is a good result for that patient but it is not rated as such with the Harris Scale. The patients also have to be co-operative and coherent for the scale to be used which poses problems for the assessment of some hip fracture patients. Furthermore, the patients have to be seen and it takes 15 minutes to administer. It should be noted that the Hip Rating Questionnaire was not selected for use in the EHFS because it had not undergone its psychometric testing when the study was designed and because not much experience had been gained with its use at that stage (Johanson et al 1992).

The three scales that follow were also used in the EHFS but have not been reported in this thesis for logistical reasons. It was decided that a scale with a rehabilitative focus should be used in the EHFS given the importance of rehabilitation in hip fracture patients. The Edinburgh Rehabilitation Status Scale (ERSS) was selected for this purpose (Affleck et al 1988). This scale was chosen because it is principally designed to assess rehabilitation and because of its specific inclusion of a social integration/isolation sub-scale which may have

proved to be an important determinant of outcome following a hip fracture. The ERSS scale also provides comparative information on both the primary and instrumental ADLs. Another reason for including the ERSS was that it was being used locally like the Harris Scale.

Patient satisfaction is becoming an increasingly more important dimension of the outcome of medical care and for this reason a satisfaction questionnaire was used in the hip fracture study for a group of self-reporting patients. The scale selected was the Patient Judgements of Hospital Quality (PJHQ) Questionnaire as it had undergone a significant amount of psychometric testing and because it dealt specifically with inpatient care.

The Katz Scale (Katz et al 1964) was incorporated into the EHFS to compare its utility in assessing the impact on the ADLs of a hip fracture patient with the Barthel Index. Part of the attraction for doing this was the minimal additional effort required on the part of the interviewer as well as the patient as much of the data required had already been collected from completion of the recommended scales.

The scales used in the EHFS are summarised in Table 3.1.

Specific questions covering demographic, medical, social and injury details were included in the EHFS. Information on comorbidity was summarised in two ways. Firstly, the medical conditions were simply summed to yield the total number of medical conditions. Secondly, the medical conditions were categorised in a manner to reflect their importance to the elderly population being studied before being summed. A value of one was assigned to each of the following seven categories : dementia; visual and/or hearing problem; cardiac condition; cerebrovascular event; chronic obstructive airways disease; arthritis; and urinary or faecal incontinence. The existence of any other comorbid condition, regardless of the number present, yielded a total value of one. The total comorbidity index defined in this way could therefore only assume a value from zero to eight and for comparative purposes perhaps gave a better overall impression of an elderly person's health than the simple summation of all their conditions. Information covering in-hospital management,

**Table 3.1** Health assessment scales used in the EHFS

Subject area	RCP & BGS recommendation	Edinburgh Hip Fracture Study <sup>a</sup>
Primary activities of daily living	Barthel Index	Barthel, Katz, ERSS, Clackmannan Scale, Harris Scale
Instrumental activities of daily living	-	ERSS, Clackmannan Scale
Communication, hearing and visual disability	Lambeth Disability Screening Questionnaire	Specific questions
Memory and cognitive function	Abbreviated Mental Test	Abbreviated Mental Test
Depression	Geriatric Depression Scale	Geriatric Depression Scale
Quality of life	Philadelphia Geriatric Center Morale Scale	Philadelphia Geriatric Center Morale Scale
Social status	Short checklist Detailed review where needed	Specific questions covering checklist, ERSS
Patient satisfaction	-	Patient Judgements of Hospital Quality Questionnaire <sup>b</sup>
Hip function	-	Harris Scale <sup>c</sup>

**Key :****a** All instruments used at baseline, one, six and 12 months unless otherwise specified**b** One and two month interviews only**c** Six and 12 month interviews only

progress and complications was also collected as the literature indicates that these factors influence outcome. The in-hospital data however was not used for predictive purposes in this thesis, as prediction is being made for patients at the time they enter the acute hospital, but will be incorporated into future multivariate analyses. Refer to the forms in Appendix 5 for more detailed information.

A more restricted range of information was obtained for patients who required an informant. Data on depression and morale were not collected. The Geriatric Depression

1989 Scale has been shown not to be valid in patients with Alzheimer's Disease (Burke et al 1992). Additionally patients in institutional care did not have data on instrumental activities of daily living, service use and social interactions outwith the institution recorded as these variables were not relevant. All baseline data collection referred to the pre-fracture status of the patient.

### 3.5.2 Selection of Outcome Variables

Most of the variables selected for the baseline interview were relevant for recording during follow-up from a descriptive point of view and these were : physical and mental health, dependency including service use, and social interactions. In addition to this, information was collected from the patients on the satisfaction with their management of their hip fracture as well as on their hip function. From a predictive point of view only a restricted range of outcome measures were examined and these were mortality, place of residence, depression, dependency, hip function and hip pain. The reasons for the selection of these variables will follow later in this section.

It also had to be decided whether the selected outcome measures would be assessed for the whole study population or the SRG only as prediction in the IRG was of more limited value for some of the variables. Further detail about this will be given in the discussion for each of the outcome variables.

One, six and 12 months post-fracture were selected as the time points to determine outcome in the EHFS based on a combination of pragmatic considerations and comparability with the literature. There is no consistency in the literature as to when short term outcome should be assessed either in general or for any specific outcome variable. In the EHFS it was decided to assess short term outcome at one month post-fracture as at this stage nearly all of the patients who did not require considerable additional rehabilitation would have returned to their original place of domicile. This may have permitted a more meaningful assessment of the impact of the hip fracture in the short term as the patients were in their pre-fracture environment compared to an assessment which had been performed at an earlier stage when the majority of patients would still have been

in a hospital setting. Medium term outcome for hip fracture patients on the whole have been reported for three to six months post-fracture with the majority reporting at six months. As a consequence of this six months was also selected as a time point for assessment in the EHFS. Pragmatic considerations also dictated a six month assessment in the EHFS as this fitted in with a six month recruitment period and any assessment less than six months would have meant that baseline, one month and six month interviews would have to have been conducted concurrently. Twelve months post-fracture is the most frequently reported long term follow-up point in the literature with very few studies extending beyond this. A notable exception to this are the selected orthopaedic series which follow-up patients for many years. Data was also collected in the EHFS at 12 months post-fracture.

Factors affecting outcome was assessed multivariately at one and 12 months post-fracture in the EHFS. The six month data was not used for prognostic purposes because the descriptive epidemiology indicated that there was a plateauing out of recovery between six and 12 months post-fracture. Additionally, most of the studies reporting prognostic information for hip fracture patients have done so for outcome at one year post-fracture.

The selection of outcome variables for the EHFS was based on a combination of the results of a literature review as well as the perceived clinical importance of the outcome. The reasons for the selection of each outcome variable, and the study population to which it was applied, will now be discussed in more detail.

Survival is a very important endpoint following a hip fracture at both the patient level and for the health and social services. The importance of this outcome is reflected by the fact that it is reported in all hip fracture studies and was selected by CRAG (1992) as one of their two outcome measures to be used for the audit of hip fracture patients as outlined in section 1.4. From a service viewpoint, survival in the short term is important as a high proportion of the cost of hip fracture patients is incurred soon after the fracture with their management in the acute hospital and then with their subsequent rehabilitation. Also, with appropriate casemix adjustment, survival may be an indicator of the quality of care.

Longer term survival is important in terms of provision and planning of appropriate health and social services. Prognostic information for survival was derived for the whole study population in the EHFS. The IRG of patients are an important group for this outcome variable as they are on the whole frailer individuals and are important consumers of health and social services.

The need to be able to predict the return home of previously community-residing hip fracture patients is gaining in importance with the need to increase the efficiency of hip fracture patient management. Using prognostic based information is now seen as the best way to identify patients suitable for the early supported discharge schemes as outlined in chapter 1. Much of the published prognostic information for short term accommodation has used the place of discharge as the outcome measure. This has the inherent difficulty however of not being a fixed point of time and may include individuals who have returned home after a protracted hospital stay. The only study to use a fixed time interval in the short term is the early work by Ceder et al (1980). As few of the IRG of patients in the EHFS were eligible for the early supported discharge schemes the analysis was limited to patients in the SRG. Another reason for selecting accommodation as a short term outcome measure was the fact that CRAG (1992) also selected this outcome for their audit of hip fracture patients. CRAG however assessed outcome at two months post-fracture and included all patients that were not in long stay NHS care. Accommodation at 12 months post-fracture was also assessed in the EHFS as this is important for health and social service provision as well as at the individual level. This analysis was also restricted to the SRG of patients as most of the patients in the IRG were already in supported forms of care at the time of their fracture.

A limited literature suggests that depression may be an important outcome to detect in hip fracture patients because it is amenable to treatment and may have an adverse effect on rehabilitation if it is not recognised. Additionally depression was one of the domains that the joint working party from the RCP and BGS recommended that should be assessed in elderly patients. As a result of these considerations depression was included as an outcome measure in the EHFS. It was assessed at both one and 12 months post-fracture.



It should be noted that no previous research has looked at the predictors of depression at one month post-fracture. The Geriatric Depression Scale which was recommended by the RCP and BGS has been shown not to be valid in patients with dementia so the analysis in the EHFS was limited to the SRG of patients.

Most of the studies looking at outcome following a hip fracture have incorporated an assessment of physical functioning which is obviously an important outcome in this group of patients. The majority of studies have reported function at six or 12 months post-fracture in terms of walking ability and/or ability to perform ADLs. Only three studies have reported physical functioning within two months of the fracture (Baker et al 1979, Barnes and Dunovan 1987, Marottoli et al 1992). In the EHFS the analysis, using the Barthel Index as the measure for dependency, was performed for both the SRG of patients and the whole study at both one and 12 months post-fracture. The analyses for the SRG of patients was performed to see the impact of the hip fracture on a group of patients who could effectively be viewed as being a 'high performing' group of hip fracture patients.

Apart from the orthopaedic studies which have specifically documented the hip function of patients who have undergone a particular operative procedure to evaluate their usefulness, there is little about hip function in an unselected series of hip fracture patients in the literature. Hip pain was recorded as an outcome measure by Mossey et al (1989) and Keene et al (1993) and the results of hip assessment were reported by Leung et al (1988) all at one year post-fracture. The paucity of research may in part be attributed to the lack of well validated scales to assess hip function. In the EHFS hip function was formally assessed at 12 months post-fracture for the whole study population. It was not assessed at one month post-fracture as examination of the patient at this stage was anticipated to be difficult and logistically it would not have been possible. Hip pain is also an important outcome measure in its own right following a fracture and as a result the predictors for this at 12 months post-fracture were also determined in the EHFS. Mossey et al (1989) are the only researchers to report predictors for hip pain and this was restricted to patients who did not suffer from dementia and were living in the community at the time of their fracture.

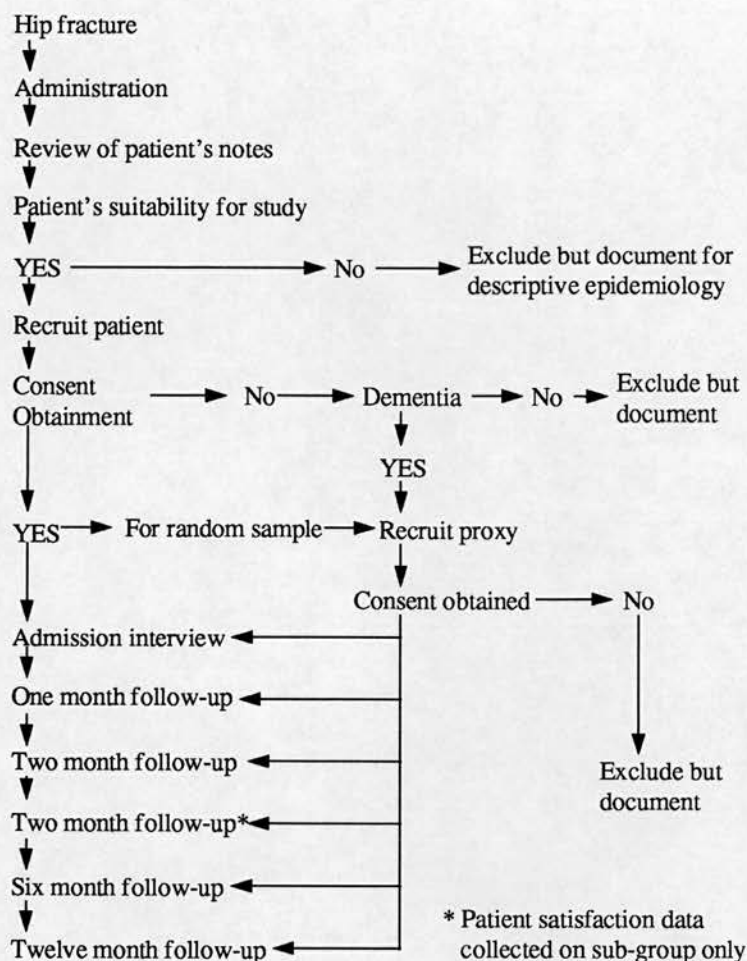
Apart from technical aspects of outcome which have been documented in the orthopaedic series of patients no further outcome measures have been reported in the literature that may have been included into the EHFS.

### **3.5.3 Interview Schedule**

The information for each patient was collected using a series of four interviews. All of the interviews were conducted at the patient's convenience. They were performed at the place where the patient was resident at the time the interview was scheduled. If the patient found any interview tiring then it was split into two or more sessions to suit the patient. The study protocol is given in Figure 3.2.

The timing of the initial patient interview was guided by the advice given by the medical and nursing staff on the orthopaedic ward. It was usually performed three to four days post-operatively when the patient was more comfortable. Also at this stage most of the acute confusional episodes, which are not uncommon in this age group, have resolved (Furstenberg and Mezey 1987, Gustafson et al 1991). If the patient had an acute confusional state which was expected to settle with appropriate management then the interview was postponed until the mental confusion had cleared. It was often necessary to contact carers to determine the pre-fracture mental state of the patient. If a patient was confused and there had been no pre-fracture history of confusion, or there was no obvious underlying medical reason for the patient's confusion, the patient was given the benefit of the doubt and permitted to provide their own information. This was subject to review at follow-up interviews. Patients who were being transferred back to their institutional care one or two days post-operatively had their mental state assessed prior to their discharge for logistical reasons.

Permission was sought from the patient's general practitioner before any follow-up interviews were performed. A copy of the individualised letter may be found in Appendix 6. In the few cases where consent was initially refused for particular patients further contact with the general practitioner resulted in consent being granted.



**Figure 3.2** Study protocol

The second interview was performed one month after the date of the patient's admission for the definitive management of their hip fracture. The vast majority of patients had been discharged from the acute orthopaedic wards at the RIE by this stage. Locating the patients did not prove to be a difficult task as the place of discharge was generally well recorded in the ward's admission book. No direct contact was needed with the patients who required a proxy at this interview as all their information was supplied by their proxy. The only exception to this was if an AMT had to be repeated on account of the baseline interview score. The majority of the proxy interviews at this stage were conducted by telephone as this proved to be the most effective way of obtaining the same proxy as at the baseline interview due to the shift work of nursing staff. It also helped ensure that a more senior member of the nursing hierarchy was interviewed as there was a tendency for the less trained staff to be volunteered if the nursing home or ward was busy if one made a personal visit. A further advantage of using telephone interviews at this stage was because of time pressure. During the first five months of conducting the one month interviews patient recruitment was ongoing whilst for the last month the six month interviews had commenced. Telephone interviews have been shown to yield comparable information to face-to-face interviews (Siemiatycki 1979, Aneshensel et al 1982, Marcus and Crane

1986). It is particularly effective for follow-up interviews after an initial face-to-face interview (Marcus and Crane 1986). The third and fourth interviews were conducted six and 12 months after the patient was admitted to the RIE. These two interview schedules incorporated a clinical examination of the patient's hip.

The SRG of patients who were admitted in the final month of the study recruitment phase had a patient satisfaction questionnaire administered to find out what they thought about their acute hospital management. These interviews were performed within two weeks of discharge in order to try to minimise any problems with recall bias and this necessitated keeping close contact with the orthopaedic wards. The group of patients who were subsequently transferred to a geriatric orthopaedic rehabilitation unit had the questionnaire repeated within a fortnight of their discharge from the unit.

Follow-up of the study cohort proved to be relatively straightforward. If there was a difficulty contacting the patient their next-of-kin was able to help. If there was no next-of-kin, or they were not contactable, a visit to the patient's place of residence usually led to the relevant information being obtained from a neighbour. Another method which proved useful in tracing patients was to contact the patient's general practitioner. One patient had to be located using the Primary Care Unit at the Northern General Hospital in Edinburgh as their new address was not known and they had changed their general practitioner.

A small number of patients moved away from Edinburgh during the course of their follow-up to be closer to their families. If their new residence was not within a 50 mile radius of Edinburgh then the relevant questionnaire was sent to the patient for completion. The questionnaires were not designed for self-completion and some sections were not suitable for this means of administration. Consequently a more limited range of information was sought from the patients and help from a carer was permitted.

#### **3.5.4 The Proxy/Patient Validation Study**

The validation study involved recruiting a second person, termed a pseudoproxy, to provide information for every patient enrolled into the study during the final month of the

recruitment phase. It provided two different types of information depending upon whether the patient required a proxy or not in the first instance. In the case of patients who did not require a proxy, the pseudoproxy yielded information on how close proxy-derived information was to that provided by the patient themselves. For patients who did require a proxy the pseudoproxy data enabled inter-observer variability to be assessed as information was being supplied for each patient by two proxies. To conduct the validation exercise it was necessary to get signed consent by the self-reporting patients prior to contacting their pseudoproxy. In the case of informant-requiring patients time was taken to explain to the informant why a second proxy was needed in order to maximise co-operation.

### **3.5.5 Data Handling**

#### **3.5.5.1 Study Log Book**

All eligible study patients were entered into a study log book. They were assigned a study number and their self-reporting or informant requiring status was recorded. Other details noted were their date of birth, date of admission, orthopaedic hospital number, ward number, the dates of their interviews over the year follow-up, and the place of discharge after their acute hospital stay.

In the back of the log book all the patients who were excluded from the study were recorded. The information was limited to name, date of birth, date of admission, orthopaedic hospital number, ward number and the reason for exclusion.

#### **3.5.5.2 Quality Control and Data Management**

In the study research instruments were used that have been previously tested for their reliability and validity.

The use of scales with a subjective component for the investigator, namely the Barthel and Katz ADL Indices, as well as the ERSS and Harris Scales, required performance review. For the first three scales this was achieved from participating in rehabilitation assessment sessions conducted by Dr L.Sloan and Ms K.MacPherson of the Cunningham Unit at the



Astley Ainslie Rehabilitation Hospital in Edinburgh. Every patient was scored individually by each assessor and the results were discussed. After four sessions all three raters were producing very similar results. Experience with the Harris Scale was obtained in the orthopaedic out-patient fracture clinics under the guidance of Mr. M.Robinson and Sr. Parker at the RIE.

Throughout the study period a book was dedicated to recording definitions and other notes to ensure consistency of data collection at all stages.

The study forms were designed to have computer compatible coding frames and were clearly formatted. At the time of the interview each form was checked for any error or transposition in the patient identification number, that all entries were legible and that there were no entries missing. A check was also made to ensure that the correct forms for the specified visit had been completed. A note was also made whether key variables such as age and birth date were consistent with one another, and whether they were in a permissible range.

The data was key punched into an IBM personal computer directly into the SAS package using specially prepared data entry screens. The accuracy of the data was checked on a random sample against the original data sheets. Frequency distributions were performed on all variables to discover aberrant values.

### **3.5.6 Verification of Case Ascertainment**

The hospitals in Lothian which manage hip fracture are the RIE, the Murrayfield and St. John's Hospital at Howden. The medical record departments were contacted and asked for a listing of all the admissions to their hospital over the study recruitment period with any diagnosis of a fractured hip using their in-house information system. Patient details specifically requested were : name, date of birth, postcode of residence, date of admission, ICD discharge diagnoses, operation codes and date of discharge or date of death where applicable. An ad hoc request was also made to the Information and Statistics Division of the Scottish Health Service to obtain a listing of all patients who had any diagnosis of a



closed hip fracture during the period of study recruitment resident in postcode sectors EH1 to EH17 inclusive who were admitted to hospital as an emergency.

### **3.5.7 Mortality Data**

All patients who were eligible for the study and died during their one year of follow-up had their death certificates reviewed at the Registrar General's Office to confirm both the date and cause of death.

## **3.6 STUDY ADMINISTRATION**

### **3.6.1 Organisation**

The setting up of the study necessitated gaining the co-operation of a broad range of people. The first step was to obtain ethical clearance from both the Orthopaedic and General Practice/Public Health Medicine Ethics of Medical Research Sub-committees to ensure that it could be conducted. No difficulties were encountered.

At the acute hospital level, on the medical side, permission had to be granted from the Trauma Group of Consultants. Mr. J.Christie, one of the supervisors of this thesis, approved the study on behalf of the consultants at the RIE. Mr. I.H.Annan, similarly granted approval on behalf of the trauma group at St. John's Hospital at Bangour. On the nursing side permission was granted to conduct the study from both the deputy director of patient services and the head of the orthopaedic unit at the RIE. At St. John's Hospital at Howden nursing permission was given by the surgical nursing administrator. The medical staff, ward sisters, medical secretaries, clerks and other members of staff in both hospitals were all personally informed about the study in order to explain its purpose as well as to gain their support and to discuss the most appropriate way of recruiting and interviewing patients.

Approval by the geriatricians in the local area consultant's group in geriatric medicine was given ensuring access to patients in the four geriatric orthopaedic rehabilitation units in Edinburgh. This was facilitated by Dr. C.T.Currie. Also permission had to be granted by the medical administrators of long stay hospitals as well as by their nursing officers in

charge. Similarly the people in charge of residential and nursing homes were contacted. All relevant staff within these institutions were contacted personally and informed of the study and enquiries were made about the best way of proceeding with the study. All of the patient's general practitioners were written to informing them about the study in order to obtain their consent to follow up their patients.

The people in charge of the medical records department at the RIE, St. John's Hospital at Howden and the Murrayfield Hospital were similarly informed about the study and their co-operation was sought in verifying the case ascertainment for the study as well as for specific patient record requests as the need arose.

### **3.6.2 Timetable**

The initial ideas for the research proposal as the basis for a PhD were first formulated in April 1991. After an extensive literature review followed by preliminary discussions with individuals, both locally and elsewhere in Britain, a pilot study was conducted in October 1991 and details of this are to be found in the following section. The findings from this study were incorporated into the definitive version of the study forms. Study recruitment began on the 1st of November 1991. The ensuing 18 months were largely spent conducting the fieldwork, designing follow-up forms, and entering and cleaning the data. During this time a successful grant application was also made to the Disability Research Committee of the Scottish Office Home and Health Department to enable the patient follow-up to be extended from six months to a year. The data analysis and the writing up phase of the study then followed. The author was appointed to an unrelated full-time position in December 1993 which slowed subsequent progress.

### **3.6.3 Pilot Study**

The pilot study was conducted at the RIE between the 18th and 23rd of October 1991. During this period 16 patients were admitted with a hip fracture. Ten of these patients were able to provide their own information and three required a proxy. Two patients had a pathological fracture and the remaining patient was very unstable medically and so would have been excluded in the main study.

All of the self-reporting patients and the three proxies gave their consent to participate in the pilot study. Additionally half of the self-reporting patients were approached to obtain the consent for the use of a pseudoproxy. No problems were encountered with recruitment. Also two of the informant requiring patients had a next-of-kin who was willing to act as a pseudoproxy. A total of twenty interviews were consequently conducted for the pilot study.

The main findings from the pilot study were that the interviews took less time to perform than originally anticipated and that they were found to be acceptable on the whole. Nonetheless the majority of people still found the baseline interview a little long. The emphasis on disability raised concern in two self-reporting patients and one pseudoproxy. The questions on social networks proved to be the most difficult. Some of the patients had trouble restricting themselves to a yes/no answer format for the morale and depression scales and also found them to be a little distressing. A look at the distribution of responses revealed the expected finding that the self-reporting patients were more medically fit and independent than those patients who required a proxy. The pseudoproxy responses were in high agreement overall with the information provided by the patient directly or by their proxy.

As a result of conducting the pilot study changes were made to the final study questionnaires. To start with the ordering of the assessment scales was altered. Specifically the Abbreviated Mental Test was brought further forward in view of the importance of a reasonable cognitive state for meaningful completion of the questionnaire.

Some of the questions for the Barthel ADL Index and the Clackmannan Scale were integrated as well as specific mobility questions without changing the essence of the questions. This helped remove some redundancy and permit a more logical flow of questioning. Individual ad hoc questions were also re-ordered, re-written or deleted to improve the questionnaires. The changes overall were fairly minor.

The source of information for particular questions was also reviewed as a result of conducting the pilot study. Some of the questions were removed for the group of patients

requiring a proxy and further questions were deleted for those patients in long stay care accommodation. It was also decided to use response cards for some questions to make it easier for patients, proxies and pseudoproxies. This also served to break the routine of question delivery. The pilot study also highlighted the need for well defined study terms. A notebook was used for this purpose throughout the study period to help ensure the recording of consistent information.

The overall length of the questionnaires was difficult to reduce without there being a substantial loss of information. Also the emphasis on disability could not be altered because it was inherent in the area being investigated.

The definitive study forms may be found in Appendix 5.

### **3.7 STATISTICAL METHODS**

This section will begin with an outline of the analyses required for the proxy/patient validation study. It is followed by a description of the survival analysis as well as the univariate and multivariate techniques used to generate regression equations for outcome variables for predictive purposes in the main study.

All of the analyses were performed using version 6.04 of SAS on an IBM 386 personal computer. Data manipulations for the survival analysis were performed on version 5 of the Excel database.

#### **3.7.1 Analysis for Proxy/Patient Validation Study**

##### **3.7.1.1 Categorical Variables**

Cohen's kappa coefficient assesses the degree of agreement between two observers for categorical data. Kappa expresses the level of agreement that is observed beyond the level that would be expected by chance alone. It is the ratio of the difference between the observed and the expected agreements, and the difference between the maximum possible agreements (1 or 100%) and the expected agreement. It has a value between -1 and +1. Kappa is positive if the observed agreement is greater than that expected by chance. A

value close to zero indicates that the agreement is no greater than would have been expected by chance whilst a negative value indicates that the agreement is less than would be expected by chance. For most purposes a value of kappa greater than 0.75 represents excellent agreement beyond chance, 0.40 to 0.75 fair to good agreement and less than 0.40 poor agreement (Sheikh 1986). As well as the standard kappa coefficient there is also a weighted form of the coefficient which takes into account the 'distance' between categories when these have a natural ordering. The variables to which the kappa statistic is being applied in this thesis do not have a natural ordering and therefore the unweighted version of the statistic is appropriate.

The percentage agreement is simply the proportion of responses that are identical between the two observers. It is subjectively judged to represent good or poor reliability as there is no standard level of agreement that is acceptable in all situations (Sheikh 1986). It is the least satisfactory way of analysing reliability because it makes no allowance for chance agreement and can therefore be spuriously high.

#### **3.7.1.2 Non-categorical Variables**

Pearson's correlation coefficient is used for numerical scales to assess the strength of the association between two variables. In this thesis Pearson's correlation coefficient has been reported in preference to Spearman's correlation coefficient because the latter does not take into account the distorting effect of any outlying values. Pearson's coefficient uses the actual numerical values of the variable. The coefficient can take the values from -1 to +1 but it is not clear how to interpret the different values of this coefficient (Bourke et al 1985). Absolute values of 0 to less than 0.3 for the purposes of this thesis have arbitrarily been deemed to indicate a weak or no association, values from 0.3 to 0.5 a slight association, values from 0.5 to less than 0.7 to indicate a moderate association, whilst values of 0.7 or more were taken to be indicative of a strong association.

One of the disadvantages of using correlations is that it may conceal significant differences in location between two sets of values (Sheikh 1986). The correlation may be excellent but the agreement is poor when one respondent consistently overestimates the rankings of



the other respondent (Nelson et al 1990). As a direct result of this it is necessary, in addition to assessing the strength of the linear association in measurements from two observers, to establish whether they differ systematically in the level of their scoring. For this purpose it is appropriate to compare the mean difference between observers the statistical significance of which can be assessed using a paired t-test.

### **3.7.2 Analysis for Main Study**

#### **3.7.2.1 Survival Analysis**

All of the patients who were not alive at one year post-fracture had their date and cause of death verified at the General Register Office for Scotland. The survival curve was obtained by plotting the proportion of survivors against the number of days post-fracture that had elapsed. For comparative purposes it was necessary to plot the survival curve for a general population which had a similar age and sex structure. This was achieved by calculating the probability of death by age and sex from the life tables for Scotland based on the actual death rates in the Scottish population in 1992 and follows the approach recommended by Bradford Hill (1966). An ad hoc request to the General Register Office for Scotland was made for this purpose as only abridged tables are published in the annual report from the Registrar General for Scotland (Registrar General for Scotland 1993). The probability of dying was calculated for each year of life by sex for the Scottish population and applied to the EHFS population. In this way it was possible to determine the number of deaths that could have been expected to occur in the EHFS population if the Scottish death rates had prevailed.

#### **3.7.2.2 Univariate Analysis**

Frequency distributions were firstly obtained on all variables to check for outlying values and missing values. Appropriate alterations to the database were then made after reviewing the questionnaires and medical records.

The shape and symmetry of the frequency distributions were also noted and this information was used to help determine the most appropriate statistical test for the univariate analysis.



The particular univariate statistical test selected was on the basis of the nature of both the predictor and outcome variable being analysed. The types of variables used in the hip fracture study were binary, categorical, ordered categorical, and continuous. The latter group included both normal and non-normally distributed variables. The statistical tests used are summarised in Table 3.2. When the chi-squared test was employed a preliminary analysis indicated the number of expected observations in each cell. This provided information as to whether the categories required condensing to make the test valid.

**Table 3.2** Univariate statistical tests

<b>VARIABLE TYPE</b>	<b>Binary</b>	<b>Categorical</b>	<b>Ordered categorical</b>	<b>Continuous</b>	
				Normally distributed	Non- normally distributed
<b>Binary</b>	Chi-squared with Yates' correction	-	-	-	-
<b>Categorical</b>	Chi-squared	Chi-squared	-	-	-
<b>Ordered categorical</b>	Mantel- Haenszel	Kruskal Wallis	Mantel-Haenszel or rank correlation	-	-
<b>Continuous Normally distributed</b>	t-test	ANOVA	ANOVA or rank correlation	Pearson's correlation	-
<b>Non normally distributed</b>	Wilcoxon rank sum	Kruskal Wallis	Rank correlation	Rank correlation	Rank correlation

The results of the univariate analyses for each outcome variable are summarised in a table.

Due to the large number of predictor variables it was necessary to limit the tabulations presented. It was decided to restrict the number of sub-categories to five for each baseline variable and only to present the results of tests which had reached the 10% level of significance. Additionally, because of their epidemiological relevance basic demographic variables were included regardless of their level of statistical significance.

### **3.7.2.3 Multivariate Analysis**

A multivariate analysis refers to any type of data analysis that takes into account a number of variables simultaneously. In this thesis the statistical methods have a common theme of

relating an outcome variable to a set of potential predictor variables. Regression is the generic name for methods of this type and the specific regression model to be applied depends upon the nature of the outcome variable. If for example, the outcome variable is binary, such as survival, then logistic regression analysis is appropriate. For an ordered categorical outcome, such as hip pain, ordered logistic regression may be used. Multiple regression may be employed for continuous outcome measures such as the Harris Scale score. The incorporation of categorical predictor variables into the models using SAS required the use of dummy variables which were set up so that the variables could only take the values of 0 and 1. It should be borne in mind that there are limitations with regression analyses and these include : no inferences about causality may be made; statistical significance does not confer clinical significance; extrapolations using data which falls outside of the range used for the independent variables which were used to generate the regression model should not be undertaken; and statistical guidance is often required to select the most appropriate regression technique as well as with the interpretation of the results (Hennekens and Buring 1987, Shott 1990). A detailed account of the regression techniques is outwith the scope of this thesis and the reader is referred to Morrison (1979), Norman and Streiner (1986), Hennekens and Buring (1979), Kirkwood (1988), SAS Institute Incorporated (1988) and Shott (1990).

As a general approach to modelling in this thesis, a hierarchical sequence of step-wise procedures was adopted. For each outcome variable selected for the multivariate analysis, the predictor variables were firstly stratified into three levels according to their importance which was based on a combination of the findings from a review of the literature and clinical judgement. The strength of the association of a baseline variable with the outcome variable and its plausibility largely guided the selection process. The number of variables in the first level was limited to around 12. This stratified approach was adopted both to minimise the effects of multiple testing, and to take into account prior information. In the initial stage of modelling the first line predictor variables for each outcome variable were added into the regression model using a forward procedure. Those terms which attained a significance level of 10% or less were then included in the model before the second line predictor variables were considered. The level of 10% is to some extent arbitrary, and a

level of say 20% could have been used instead. The conventional 5% level was not used as there was prior evidence of association for the variables being dealt with, and the purpose of the analysis was for prediction rather than significance testing.

The stability of the regression model obtained from the forward stepwise procedure was then examined by performing a backward regression. This technique involved fitting a model which initially included all the first line variables and then removing the non-significant terms one at a time starting with the least significant term. This was continued until only significant terms were left in the model. If the regression models from the both the forward and backward methods yielded the same significant predictor variables then this implied that the regression model was robust. This was only done for the first level variables due to the difficulty in the simultaneous fitting of a large number of variables.

Having ascertained that a robust regression model was obtained with the first line variables the next stage was to add in the second line variables. To do this the significant first line variables were forced into the model before the second line variables were entered. A forward stepwise procedure was then performed and second line variables were included if their significance attained a level of 5% or less. This procedure was then repeated with the significant 1st and 2nd line terms in the model and 3rd line variables with a significance level of 1% or less were added.

The definitive regression model was finally obtained by re-running the SAS program including only the significant 1st, 2nd and 3rd line variables. This was required to overcome the loss of information due to missing values in the non-significant variables, as multiple regression can only be applied to subjects with complete data for all variables being considered.

A flexible approach was adopted in selecting models for the prediction of outcome. For example, multiple regression techniques can sometimes lead to coefficients for a variable being of opposite direction to that seen in univariate analyses, and of a sign which would cause the prediction formula to lack face validity. In most cases this is an artefact due to

the relationship between predictor variables, or may, in terms of plausibility, be ascribed to chance, and in instances where this has occurred such terms have been removed from the model. Such an approach is equivalent to applying one-tailed tests of significance to certain predictive variables. If forward and backward procedures gave different models in the first stage, selection was based on which variables would be the most easy to use predictively.

The interpretation of the 'independent' predictors should take into account the fact that the statistical significance of any baseline variable depends on which other variables are in the model. Thus, some variables may be 'independent' predictors because they entered a model before a confounder, but would be non-significant if the confounder was already present in the model.

Once the prognostic indices were derived receiver operator characteristic (ROC) curves were generated to assess the relationship between the sensitivity and specificity of the index when applied to the original data set. This was performed to gain an indication of the utility of the indices. The areas under the ROC curves yielded further information about the usefulness of the prognostic indices. Further detail about ROC curves was given in section 2.4.4.2. However it should be noted that this approach gives a biased estimate of the index due to the same data set being used to generate and subsequently assess its performance and a subsequent study is required to validate the index. Nonetheless it still indicates the potential of the index.

### **3.8 SUMMARY**

This chapter has outlined the methodology used in a prospective longitudinal population-based study looking at the outcome of 270 patients with a hip fracture. The chapter has covered the areas of study design; sample size; patient inclusion and exclusion criteria; patient identification and selection; data collection, including the selection of specific research instruments and outcome variables; organisational aspects including the pilot study; as well as outlining the statistical methods that were employed for the analysis. Features of the design which cumulatively make the EHFS innovative are : use of an

unselected large series of patient; wide range of baseline and outcome variables included; serial follow-up to one year; usage of the scales recommended by the RCP and BGS for comprehensive assessment of the elderly; incorporation of a nested validation study to assess the comparability of informant derived data; and the employment of multivariate methods of analysis.



## **CHAPTER 4**

### **DESCRIPTIVE EPIDEMIOLOGY FOR STUDY POPULATION**

#### **4.1 INTRODUCTION**

The purpose of this chapter is to present the descriptive epidemiology for the Edinburgh Hip Fracture Study population. It will begin with a review of the recruitment of the study population and the completeness and quality of the data collection. The results for the proxy/patient validation study will then be presented followed by an outline of the baseline characteristics for the EHFS population. A review of the inter-relationships between the baseline variables to establish possible confounding variables to help with the interpretation of the subsequent multivariate analysis will then be presented. Follow-up data is then given for the whole study population and for the survivor cohort only in order to investigate the possible distorting effect of the frailer individuals not surviving to one year post-fracture. A discussion and summary of the main results conclude the chapter.

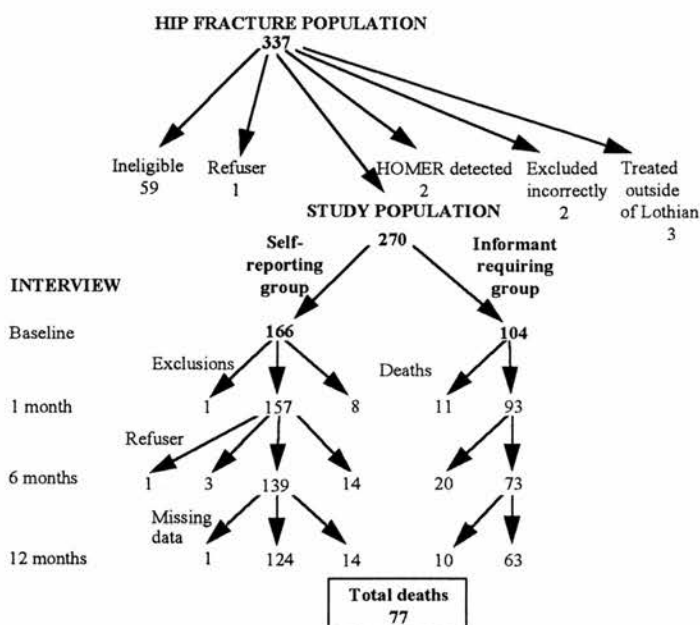
The data which forms the basis for this chapter is tabulated in Appendix 7 due to its extensive nature.

#### **4.2 STUDY POPULATION**

##### **4.2.1 Recruitment**

Over the six month period from 1st November 1991 to 30th April 1992 337 patients who lived in postcode areas EH1 to EH17 inclusively sustained a hip fracture and were admitted to an acute hospital. See Figure 4.1. Three of the patients were treated in hospitals outside of Lothian. Of the remaining 334 patients 275 were eligible for the EHFS and all but five of these patients were recruited. Of the five patients who were potentially eligible but were not included, one patient refused, two patients were excluded incorrectly on the basis of their place of residence, and the other two patients were detected on the Royal Infirmary of Edinburgh patient information system after the recruitment phase had finished. The patient who refused to participate was a registered blind lady.





**Figure 4.1** Hip fracture population at baseline and follow-up interviews

Sixty patients were excluded from the study including the one patient who refused. Patients may have been excluded for more than one reason and a total of 67 reasons for exclusion were obtained. Seventeen patients were less than 60 years of age at the time of their fracture. Major trauma was the cause of the fracture in seven patients. Four of these patients sustained their

fracture as a result of a road traffic accident, one from a football injury and the remaining two from injury sustained during an epileptic fit. Twenty patients were obviously moribund at the time of their admission or died within a week of their hospitalisation. Eleven patients had pathological fractures. Six of these patients had metastatic deposits at their fracture sites, three being due to lung cancer, two from prostate cancer and one from breast cancer. Another patient fractured his hip at the site of previous deep X-ray therapy for a secondary deposit from his prostatic cancer but there was no sign of recurrence of the cancer at operation. Two patients sustained a fracture through their hip arthrodesis this being performed for a chondrosarcoma for one patient and for recurrent hip dislocations in the other. A teenage boy with profound cerebral palsy fractured his hip as did a middle aged man with polio. Nine patients were excluded on the basis of the presence of a medical condition which interfered with the assessment of their hip fracture. The reasons included : a fractured humerus sustained one month before the hip fracture; a severe episode of Crohn's disease; profound depression; severe Parkinson's disease; an extension of a cerebrovascular accident at the time of the fracture; a subarachnoid haemorrhage; profound deafness and no known next of kin to act as an informant on

patient's behalf; a spiral fracture of the shaft of the femur which extended up into the intertrochanteric area (two patients). Two patients had avascular necrosis of their hips at presentation and it was plausible that their original injury may have occurred within the recruitment period of the study. However because their fracture was obviously not fresh they were excluded from the EHFS. The final patient to be excluded was the blind lady who refused to participate in the study.

166 patients were able to provide their own information and 104 required an informant. These two groups of patients were called the self-reporting group (SRG) and the informant requiring group respectively (IRG). The leading reason for requiring a proxy was the presence of Alzheimer's Disease and this accounted for 101 of the IRG of patients.

The remaining three patients in the IRG had an expressive dysphasia secondary to a previous stroke.

#### **4.2.2 Case Ascertainment**

This was undertaken by obtaining a patient listing from the HOMER information system at the RIE as well as from the Information and Statistics Division (ISD) of the Scottish Health Service.

The data from HOMER was used to obtain a quick verification of the patients admitted to the RIE. Every patient admitted to the RIE with any diagnosis of a hip fracture between 1st November 1991 and 30th May 1992 was requested. At the conclusion of the patient recruitment phase for the EHFS it was noted that two patients who were on HOMER had not been recruited into the EHFS. Further cross checking of the patients in the EHFS and the patients obtained from the HOMER listing revealed that 31 patients were recruited into the EHFS but had not been recorded on HOMER.

An ad hoc request was made to the Information and Statistics Division of the Scottish Health Service for all emergency closed hip fractures for people resident in postcode sectors EH1 to EH17 inclusive over the period 1st November 1991 to 30th April 1992 for

a more definitive verification of case ascertainment for the EHFS. Details on the date of birth, sex, date of admission, date of discharge, ICD diagnostic code(s), and operation code(s) were also requested. Emergency admissions were specified so that the transfer of patients to rehabilitation hospitals would not be counted as another episode. Open fractures were not included as these are likely to be the result of significant trauma. The original request produced a listing of 65 patients who were in the EHFS but were not recorded by ISD. These records were double checked and all but 13 were due to the patient being transferred from a long stay care facility with a fresh hip fracture. Nine of the 13 patients did not have any diagnosis of a closed hip fracture and the other four patients could not be located at all. The ICD codes for the nine patients who did not have a diagnosis of a closed hip fracture were requested from ISD. Three of these patients had an ICD code of 821.0 which represented a closed fracture of the shaft or unspecified part of the femur. One patient had a code of 822 recorded for her fractured patella but no 820 code for her hip fracture. A patient with a fracture through a metastatic cancerous deposit in her hip was coded as having a pathological fracture. A further patient who had sustained a fracture through a previous hip arthrodesis was coded as having a complication of a previous internal orthopaedic device. One patient was miscoded as 870.0. Of the two remaining patients one patient had been coded as having an unspecified disorder of a joint whilst the other was coded as having unspecified backache. It was interesting to note that of these nine patients who had not been recorded as having a hip fracture two of the patients had been correctly coded on HOMER suggesting that the SMR1 form had been correctly completed but that a coding error had occurred at ISD. However, it was also interesting to observe that 10 patients who were on the SMR1 listing from ISD were not on the list obtained from HOMER.

The SMR1 patient listing from ISD also yielded 17 patients who had not been considered for the EHFS. A review of their orthopaedic notes revealed that eight of these patients had a minor fracture of their hip. These minor fractures cannot be distinguished from intertrochanteric fractures as they have the common ICD rubric of 820.2 in the 9th version of the ICD classification (WHO 1977). See Appendix 1. Six patients had their medical condition incorrectly classified as a hip fracture these being : fracture of the pubic ramus

(two patients), soft tissue injury to hip, fractured shaft of femur, fractured neck of humerus, laceration to thenar eminence of thumb. Three patients were on the SMR1 listing but were not recruited into the EHFS because of incorrect coding of their place of residence. One patient had their postcode sector recorded as EH14 when it should have been EH20. One patient had moved into a nursing home outside the study boundary and her new address had not been used. The other patient lived in Glasgow but was visiting a friend in Edinburgh and the friend's address was incorrectly used as the usual place of residence. The remaining two patients that were on the SMR1 listing but not in the EHFS were the two patients that had been detected by HOMER and had inadvertently not been included in the EHFS.

No potentially eligible patients were admitted to the Murrayfield Hospital or St. John's Hospital at Howden over the recruitment period.

The overall ascertainment of cases for the EHFS was 99% as 332 of the 334 hip fracture patients managed in an acute hospital setting in Lothian were registered in the study. It should be noted that individuals who sustained a hip fracture but were not admitted to an acute hospital are not included in the denominator. There is however no straightforward way of identifying these patients but the number involved is likely to be small. The denominator does also not include the three patients who were treated in hospitals outside of Lothian according to cross-boundary information supplied by the Information Services Division (Murphy 1993). No further medical information on these patients was sought and consequently it was not known if these patients would have fulfilled all the entry criteria to be eligible for the EHFS.

The age- and sex-specific incidence rates for residents of Edinburgh living in postcode sectors EH1 to EH17 inclusive are shown in Figure 4.2. The denominators for the calculations were obtained from the 1991 census from SASPAC supplied by Manchester Computing Centre (1992).

4.2.3 Completeness of Data

A summary of the data collected throughout the study is given in Figure 4.1. Of the 275 eligible hip fracture patients 270 were recruited into the EHFS.

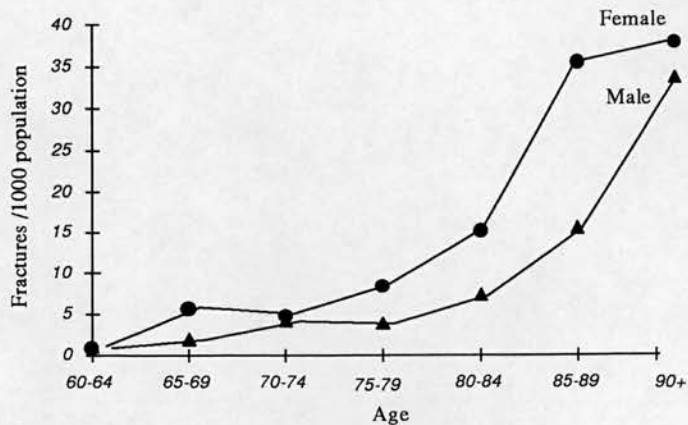


Figure 4.2 Age- and sex-specific incidence rates

4.2.3.1 Mortality

Of the study population 19 (7%) had died at one month post-fracture, 53 (20%) at six months and 77 (29%) at 12 months as shown in Figure 4.1. The corresponding figures for the self reporting group were 8 (5%), 22 (13%), and 36 (22%). For the informant requiring group the figures were 11 (11%), 31 (30%) and 41 (39%) respectively. The survival curve for the study population is given in Figure 4.3.

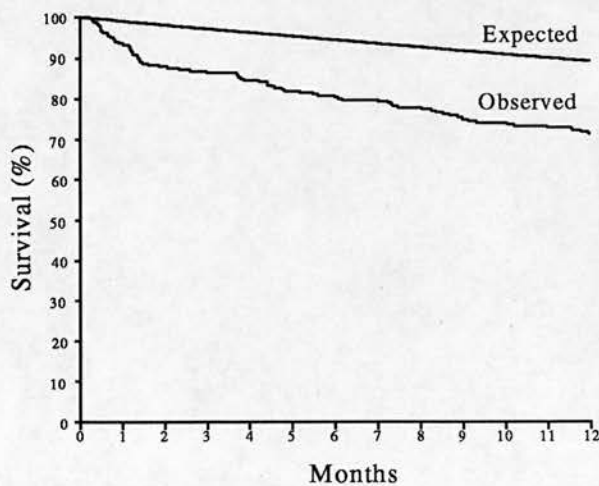


Figure 4.3 Survival curve

The death certificates were reviewed at the Registrar General's Office for Scotland and the underlying cause of death was ascertained for the 77 patients who died within the year of follow-up. The death of 12 (16%) patients was directly attributed to their hip fracture. Respiratory tract disorders were recorded as being a contributory factor for death in eight of

these patients with four being due to pneumonia, three to bronchopneumonia, and one to respiratory failure. In two patients infection of their fractured hip contributed to their death. One patient had an infected prosthesis and the other patient had an infected wound. Of the remaining two patients who had their underlying cause of death recorded as a hip



fracture one patient had 'old age' listed as a contributory cause whilst the other patient, who was 101 years old, had no extra diagnoses listed.

Sixty five patients (84%) did not have their underlying cause of death recorded as being due to their hip fracture. The main cause of death was circulatory disorders accounting for 39 (51%) of the 77 patients who died. Twenty of these patients died from heart conditions of which, six were recorded as being due to acute myocardial infarction, nine as chronic ischaemic heart disease, two as hypertensive heart disease and the remaining two as heart failure. Sixteen patients were reported to have died from cerebrovascular disease. Five of these patients were coded as dying from occlusion of the cerebral arteries, nine for acute but ill-defined disease and the other two for other ill-defined disease. The remaining three patients who died from circulatory disorders had one of the following diagnoses : generalised and unspecified atherosclerosis; ruptured aortic aneurysm; or ulcerated and infected varicose veins. Respiratory conditions were listed as causing 12 (16%) deaths. Bronchopneumonia, pneumonia, aspiration pneumonia, chronic bronchitis, chronic obstructive airways disease not elsewhere specified, and adult respiratory distress syndrome accounted for three, one, one, two, four, and one death respectively. Two (3%) deaths of deaths were attributed to digestive tract disorders. One patient had an infective gastroenteritis recorded as her underlying cause of death whilst the remaining patient died as a result of asphyxiation from a foreign body.

#### **4.2.3.2 Medical Exclusions**

Four medical exclusions were made during the course of follow-up on the basis of the individual sustaining a medical event which significantly interfered with the assessment of the outcome from their hip fracture. Two patients suffered a cerebrovascular accident, one patient required bilateral lower limb amputations for her severe connective tissue disease and another patient had severe thyrotoxicosis. Fuller details are provided in Appendix 8. All were known to be alive at the end of the year of follow-up and were included in the mortality analyses but not for the other outcome measures of interest.



#### **4.2.3.3 Drop-outs**

One patient refused follow-up to one year post-fracture. Information at one month post-fracture was obtained for this individual and survival status was known at six and 12 months.

#### **4.2.3.4 Partially Missing Data**

Two patients refused their six month follow-ups but consented to be followed up at one year.

During the course of follow-up four self-reporting and one informant-requiring patient moved away from Edinburgh. A more limited range of information was collected on these patients as they were followed up by questionnaire, and completed by a proxy in the case of the latter patient. The AMT and the hip examination were necessarily omitted.

Two self-reporting patients died at the time their one month interview was pending and a further three at six months. Information on these patients was collected from an informant as they were all in hospital at the time of their death.

Five patients had mild impaired cognitive function at baseline which had previously been undocumented and was attributed to the peri-operative events. During follow-up their cognitive functioning declined as a result of the progression of their dementia and they required an informant.

One informant-requiring patient would not complete the AMT at baseline due to his paranoid psychosis but was more amenable to being interviewed at later stages of the follow-up. The AMT was not performed after baseline for three patients with an expressive dysphasia. Testing cognition in patients with very severe dementia was difficult.

One patient was in South Africa when her one month interview was due so her one month data was not collected.

Full details about the acute hospitalisation experience of three patients could not be obtained as their case notes went missing. Additionally the 12 month follow-up data on a self-reporting patient was mislaid.

Detailed information on the patients analysed for each of the outcome variables will precede their univariate analyses in chapters 5 and 6.

#### **4.2.4 Quality of Data**

Considerable thought at the design stage of the EHFS was given to the issue of data quality and procedures were formulated so that the best quality data could be obtained within the pragmatic constraints of the study.

Experience with the administration of standardised assessment scales was gained by the author prior to the start of the study as indicated in section 3.5.5.2. The guidelines for the use of the scales were reviewed regularly to minimise problems with interviewer drift which was outlined in section 2.5.2. No formal intra-reliability testing was performed. All of the data collection was performed by one person.

Data collected from patients and proxies were cross-checked with information available in the medical records and any discrepancies were investigated and if necessary the patient's general practitioner was contacted to clarify any inconsistencies. Information on date and cause of death of study patients from informants was verified by cross-checking against death certificates.

At interview if the patient seemed confused, and there was no history of confusion, then the interview was delayed until it settled. The AMT was used as a screening test to detect an impaired cognitive state and useful information was also often obtained from nursing staff. If an informant was required to obtain reliable information then attempts were made to recruit the person who knew the patient best and to use the same informant at subsequent interviews. A nested proxy/patient validation study was also performed to check the comparability of data from different sources.

All the data collection forms were checked for their completeness on the day of use and all attempts were made to minimise any missing data. The accuracy of the data entry was cross-checked against the original data collection sheets for a random sample. Periodic frequency distributions of the study variables were also obtained to discover any outlying values.

### **4.3 THE PROXY/PATIENT VALIDATION STUDY**

#### **4.3.1 Introduction**

At the design stage of the EHFS it was recognised that a number of hip fracture patients would not be able to provide their own information, or only be able to provide information which was of impaired quality. To overcome this problem an informant, termed a proxy, was recruited to provide data on their behalf. This enabled an additional 104 patients to be enrolled into the study. The benefits arising from this included a larger sample size over a fixed six month recruitment period and a more representative sample of hip fracture patients. However it was necessary to ensure that the information provided by the proxies was comparable to that provided by the patients themselves, had they been able to do so. To investigate this, a nested proxy/patient validation study was incorporated into the EHFS.

#### **4.3.2 Methods**

All patients who were eligible for the main study during the final month of the recruitment phase formed the potential study population for the validation study. All of these patients were approached to gain their consent to use a proxy where this was appropriate. The proxy recruited was the patient's main helper. In the case of institutionalised patients a second key carer was selected to be the proxy. To distinguish the informants recruited for the validation study from the main study they were termed pseudoproxies.

The pseudoproxy data for the patients in the SRG enabled a comparison of how close the data was from the two different sources. The pseudoproxy data for the patients in the IRG enabled inter-observer variability to be assessed as effectively two informants were being recruited for each of these patients. The data was analysed separately for the

pseudoproxies for the SRG and the IRG due to the different dimensions of data quality that they were assessing. The approach to the statistical analysis has been outlined in section 3.7.1.

**4.3.3 Results**

All 41 patients who were entered into the main study during April 1992 had a pseudoproxy recruited. One pseudoproxy had a personality disorder and this limited the information she was prepared to provide. This was the only problem encountered in the conduct of the study.

The group of patients in the validation study were representative of the whole study population in terms of their basic demographic characteristics, physical and mental health as well as in their dependency level. Key variables are summarised in Table 4.1.

**Table 4.1** Comparison of baseline characteristics of patients in validation study and main study

Baseline variable	Study N (%) or means (SD)	
	Validation (N=41)	Main (N=270)
Age	81.9(7.6)	81.1(8.1)
Female	33(80.5%)	221(81.9%)
Self-reporting	28(68.3%)	166(61.5%)
Unsupported form of accommodation	27(65.9%)	175(64.8%)
Lived alone	17(41.2%)	101(37.4%)
Very good general health	41(31.7%)	80(29.6%)
AMT score	7.0(3.4)	6.8(3.4)
Total Barthel score	17.2(4.1)	16.7(4.2)

**4.3.3.1 Pseudoproxy Data for Self-reporting Group**

The pseudoproxy data came mainly from relatives, the majority of whom did not live with the patient. The pseudoproxies who lived with the patients were : two wives, four husbands, one brother, and one daughter. The pseudoproxies who did not live with the patients were : three sisters, four daughters, three sons, one son's wife, three nephews, three wardens, one neighbour, and one friend.

#### 4.3.3.1.1 Qualitative Variables

Refer to Table 4.2 for a summary of the kappa statistics and the percentage agreements for the categorical baseline variables in the validation study. One patient could not recall where she fell and broke her hip and one pseudoproxy, who had a personality disorder, would not answer the questions on social interactions.

**Table 4.2** Inter-observer reliability for categorical variables

Baseline variable	SRG of patients			IRG of patients		
	N	Kappa statistic	Percentage agreement	N	Kappa statistic	Percentage agreement
Marital status	28	1.00	100	13	0.82	92
Mechanism of injury	28	N/A*	89	13	1.00	100
Where injured	27	1.00	100	13	1.00	100
Place of injury inside	28	0.66	75	13	0.48	62
Mechanism of fall	28	0.48	68	13	0.54	69
Who patient visited	27	0.42	70	13	0.73	85
Who visited patient	27	0.29	59	13	0.51	69

\* Kappa statistic could not be calculated as the pseudoproxies all used the same response category

Only the variable 'who visited the patient' had a poor agreement when analysed using Cohen's kappa statistic. The majority of variables fell into the fair to good agreement range. The variables marital status and where the patient was injured attained excellent agreement. It should be noted that a kappa statistic could not be calculated for the mechanism of injury variable because the pseudoproxies always used the same response category.

The percentage agreements ranged from 59% to 100% which subjectively indicate good to perfect reliability.

#### 4.3.3.1.2 Quantitative Variables

In Table 4.3 correlations are presented for selected baseline variables which were determined to be independent predictors for the outcome measures investigated in the EHFS. See chapters 5 and 6 for further detail on the derivation of the predictor variables.

Strong associations were found for the majority of variables with the more objective variables, such as the type of walking aid used by the patient, attaining the highest correlations.

**Table 4.3** Inter-observer reliability for ordered categorical and continuous variables

Baseline variable	SRG of patients		IRG of patients		Whole study population	
	N	Correlation	N	Correlation	N	Correlation
Accommodation	28	0.88	13	0.99	41	0.98
Co-residents	28	0.71	13	1.00	41	0.89
General health	28	0.31	13	0.56	41	0.44
Vision	28	0.91	13	1.00	41	0.94
Number of categorised medical conditions	28	0.82	13	0.47	41	0.77
Inside walking aid	28	0.97	13	0.96	41	0.96
Maximum walking distance	28	0.74	13	0.78	41	0.75
Managed on a daily basis	28	0.28	13	0.55	41	0.40
Total Clackmannan score	28	0.81	4	0.97	32	0.84
Clackmannan self-care subscore	28	0.83	13	0.97	41	0.91
Total Barthel score	28	0.56	13	0.73	41	0.69
Barthel mobility subscore	28	0.67	13	0.72	41	0.73
Barthel self-care subscore	28	0.06	13	0.61	41	0.42
Main helper	28	0.85	13	0.98	41	0.92
Religion	28	0.65	13	0.92	41	0.67
Frequency of church attendance	28	0.91	13	0.79	41	0.89
Others rely on patients for help	28	0.66	13	0.61	41	0.65



Patients were more likely to report better general health and mobility, less dependency, and fewer social contacts than their pseudoproxies. To investigate whether there was any systematic respondent bias paired t-tests were performed for the difference in mean values for the patients and the pseudoproxies. The only variable to reach significance, after using a Bonferroni approach to allow for the effects of multiple testing, was the total Barthel score. The mean difference between the patients and the pseudoproxies was 5 points (SD 2.3), on the 0 to 20 point scale, with the patients reporting the higher scores.

#### **4.3.3.2 Pseudoproxy Data for Informant-requiring Group**

The proxies for the IRG of patients in the validation study were : one wife, three daughters, two wardens, and seven nurses. Two of the daughters lived with the patient. As far as the pseudoproxy data was concerned the information came from : three daughters, two sons, one niece, five nurses and two enrolled nurses. Four of the patients had both sets of information coming from staff nurses, two from a staff nurse and an enrolled nurse, two from daughters, and two from unmatched relatives.

Only 13 patients requiring a proxy were eligible for the study during the final month of the recruitment phase of the main study. This small sample size necessarily limited the usefulness of the pseudoproxy data analysis. Furthermore, patients who were in institutional care had a more restricted range of baseline data collected, for example information on the instrumental activities of daily living were not sought, which meant that for some variables only five patients were in the analysis. The small numbers in the analyses should be borne in mind when interpreting the results.

##### **4.3.3.2.1 Qualitative Variables**

Refer to Table 4.2. Four of the reported kappa statistics reflected fair to good agreement between the proxy and pseudoproxies responses. The other three variables were all in the excellent range with two demonstrating perfect agreement.

The percentage agreements ranged from 62% to 100% indicating good to perfect reliability without taking the role of chance into account.

#### **4.3.3.2.2      Quantitative Variables**

Pearson's correlations are reported in Table 4.3 for the proxies and pseudoproxies of the IRG of patients and clearly indicate strong associations for the majority of variables presented. Forty seven percent of the correlations attained values of over 0.90. As for the SRG of patients the more objective criteria obtained the highest correlations.

None of the mean values of the variables in Table 4.3 were significantly different when analysed using paired t-tests indicating that the source of the proxy data did not have a significant bearing on the data obtained.

#### **4.3.4      Discussion**

Misclassification bias is an issue which requires consideration in the present study because of the different sources of information about the patients. This was not an issue for the analyses conducted for the SRG of patients only as all the data was collected from the patients themselves. However for the whole study analyses two sources of information were used and these were the patients themselves for the SRG of patients, as just mentioned, and informants for the IRG of patients. In the EHFS the majority of the patients were self-reporting. Patients who required an informant were mostly in supported forms of care and therefore their informants would have been directly observing their behaviour. The reporting biases from these informants is likely to be small compared to the average differences between the SRG of patients, who on the whole were reasonably fit individuals in the community, and the IRG of patients who were much frailer and in supported accommodation. Nonetheless it was still necessary to establish whether the patients and informants provided comparable information.

The analyses of the responses for the SRG of patients and their pseudoproxies yielded information on how close the surrogate responses were to that of the patient. The responses ranged from no association to an excellent association with the majority being at the more favourable end of the spectrum as shown in Tables 4.2 and 4.3. The nature of the variable had a marked influence on the strength of the association. The activities that were more readily observable and less private yielded greater agreement and this supports

the findings of Magaziner et al (1988). The hip fracture population investigated by Magaziner et al (1988) was very comparable to the SRG in the current study. Walking aid use had the highest agreement and the variables gauging more general attributes, such as overall health, had the lowest in both studies. It was interesting to note that the self-care subscale score of the Barthel Index yielded a particularly low correlation of 0.06 indicating little association. Reviewing the percentage agreements for each of the self-care variables revealed that the lowest percentage agreement was obtained for bathing and the highest for toileting being 68% and 96% respectively. The reliability for the self-care variables was analysed in this way so that a direct comparison with the study by Kivela (1984), who also studied an elderly population, could be made. The results from the two studies were comparable. Magaziner et al (1988) reported a similar hierarchy in the percentage agreements for their hip fracture patients. A significant difference in the responses for patients and informants for the primary activities of daily living, as well as for the instrumental activities, using an adapted form of the OARS Multidimensional Functional Assessment Questionnaire (Fillenbaum 1978) was also reported by Magaziner et al (1988). The Pearson's correlation coefficient of 0.61 derived by Magaziner et al (1988) for their PADL was very similar in magnitude to the 0.56 obtained in the current study.

The pseudoproxies tended to underrate the patient's functional ability in the present study using the patient's own assessment as the gold standard. The total Barthel score was however the only variable for which a significant difference in response was obtained this being 5 points (SD 2.3) on a 20 point scale. Other studies to find reporting bias in function for elderly patients include Rubenstein et al (1984), Elam et al (1991) and Dorevitch et al (1992). Rubenstein et al (1984) have summarised possible reasons for the reporting bias and these were mentioned in section 2.5.3 and are brought together here. Firstly, patients may overrate their abilities by using denial as an adaptive mechanism psychologically or they may be trying to conceal their disability in order not to be a burden. If they are in a hospital setting the patients may simply be being optimistic in order to facilitate an earlier return home. A community informant on the other hand may exaggerate their caregiver role, either subconsciously or consciously, in order to elicit sympathy or to expedite the admission of the patient to supported accommodation.

Alternatively they may be being overprotective or simply misinformed. An informant from an institution may assume that a patient has certain disabilities rather having objective evidence. A patient may be disorientated in a hospital environment, at least initially, and a hospital setting is also conducive to increasing dependency and this may additionally lead to an underestimate of a patient's capability.

In the current study an objective assessment of the patients functional capacity was not made as it was the pre-fracture capacity which was of interest, so that the validity of the patient and pseudoproxy responses could not be evaluated. Elam et al (1991) and Dorevitch et al (1992) did however include direct observation into their study protocols thereby enabling the validity of the responses from the different sources to be assessed. Both studies found that the patient reports were more accurate than those of their informants and concluded that data should be sought from the patients themselves rather than from an informant.

The results for the analysis looking at the closeness of the data provided by the SRG of patients and their pseudoproxies would have been more favourable if the two patients who were quite vague at the time of their initial assessments had been excluded from the analysis. One patient had a complicated post-operative recovery with an episode of cerebral hypoxia whilst the second patient was a poorly controlled diabetic. Both patients had borderline scores on cognitive testing but were given the benefit of the doubt as neither had a confirmed past history of confusion or dementia. The two patients were not excluded from the validation analysis as they were included in the main study as self-reporting patients and therefore their inclusion into the validation study would make the sample more representative of the main study population.

Twelve out of the 17 correlations for the variables for the responses from the informant for the IRG of patients and the pseudoproxy were strong. No significant inter-observer variability was observed as indicated by the fact that no significant differences for the mean values for the variables from the two different sources were obtained. This indicated that the choice of proxy was not crucial. It should be noted that the correlations for the inter-



observer study were higher than that obtained for the SRG and pseudoproxy analysis because the narrower range of responses for the SRG had the effect of producing smaller correlations.

Due to the small number of pseudoproxies recruited into the EHFS it was not possible to analyse the potential effect of the relationship of the pseudoproxy to the patient, or the frequency of their contact with the patient, on the correlation of the responses. Work by Magaziner et al (1988) has suggested that proxies who are young, female, live with the patient, assist the patient with their activities of daily living, or who are not first degree relatives of the patient significantly underrate the patients functional ability. Significant differences have also been reported for different types of informants in institutions with nurses rating patients as more dependent than physiotherapists (Malzer 1988).

On the basis of the findings from the validation study for the EHFS it is reasonable to use informant derived data as a substitute for the patient when the patient is unable to provide good quality data. The only exception to this is dependency as gauged by the Barthel Index where there is a bias with the patients rating themselves as less dependent than their informants. This finding is confirmed in the literature. The inter-observer study indicated that the choice of proxy used in the EHFS was not critical. In retrospect the issue of reliability of data in the EHFS would have been improved if the intra-individual variability in patient and informant responses had also been assessed.

#### **4.4 BASELINE CHARACTERISTICS**

The main focus of the results will be on the whole study population. The classification of patients into self-reporting and informant requiring was unavoidable and was based on the quality of the information that they could provide. The SRG of patients was largely comprised of individuals who were community dwelling whilst the IRG of patients was mainly people with dementia, most of whom were in supported or institutional care. Data on psychological variables were not collected on the IRG of patients and additionally questions were not asked if they were not applicable to individuals in institutional care such as the instrumental activities of daily living. In the following presentation results from

the total study population will be given, with separation into the SR and IR groups of patients only to highlight interesting differences between them. The baseline data collected from the patients, or their informants, referred to the pre-fracture status of the patient. The data is summarised in Table 1 of Appendix 7.

### 4.4.1 Demographic

The age distribution of the study population is given in Figure 4.4. The average age of the SRG at the time of their fracture was 79 (SD 7.9) years whilst for the IRG it was 84 (SD 7.5) years and this difference was statistically significant. The male to female ratio was approximately 1 : 4. The age- and sex-specific incidence rates are presented in Figure 4.2. The marital status of the study

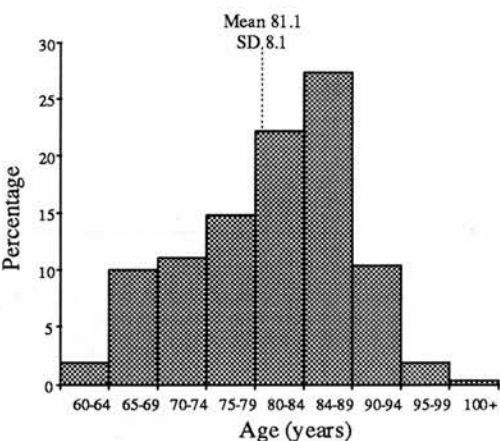


Figure 4.4 Age

population is given in Figure 4.5 and social class in Figure 4.6. The average length of schooling was just under 11 years. Overall 59% of the study population owned their own homes. Fifty eight percent of the study participants lived in their own homes prior to their fracture. A significantly higher proportion of the SRG however contributed towards this overall figure with 81% living in their own homes compared to only 22% in the IRG.

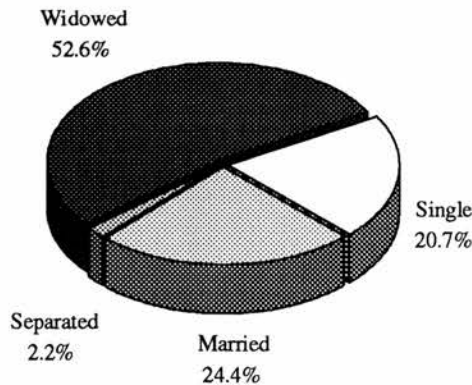


Figure 4.5 Marital status

65% of the IRG lived in residential or more supported forms of care. The distribution of accommodation for the whole study population is given in Figure 4.7. Just over 50% of the SRG lived on their own prior to their admission for their hip fracture compared to 15% of the IRG. Overall 37% of the whole study group lived on their own. See Figure 4.8.



#### 4.4.2 Injury

Forty nine percent of the hip fractures were extracapsular. Individuals who sustained an extracapsular fracture were significantly older and had a poorer level of cognitive functioning on average than patients with an intracapsular fracture.

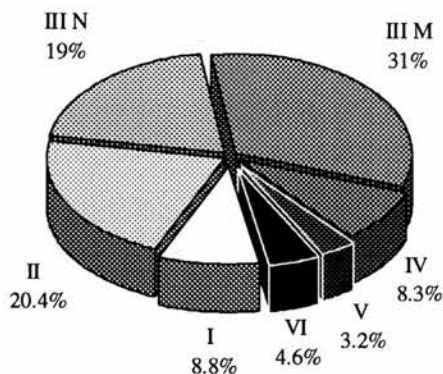


Figure 4.6 Social class

Ninety six percent of the hip fractures occurred as a result of a fall. Three percent, or seven fractures, occurred spontaneously. Four of these patients were on steroid therapy. Two further fractures were secondary to a low velocity car accident and three patients

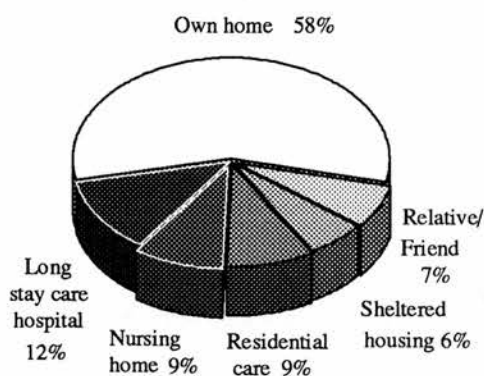


Figure 4.7 Accommodation

could not recall the circumstances of their fracture.

The mechanism of fall was classified using the St.Louis Oasis Classification (Lach et al 1991).

Thirty four percent of the falls occurred as the result of an external factor such as a trip over an object. Thirty six percent were directly

attributable to an internal factor, such as the patient's legs giving way or a visual problem initiating the fall. A further eleven percent were classified as being non-bipedal in origin. These represented falls which were self-generated, such as falling out of bed, or support failure, such as a chair collapsing for example. Twenty percent of the falls were non-classifiable because the cause of the fall was either not known by the patient or there was inadequate data.

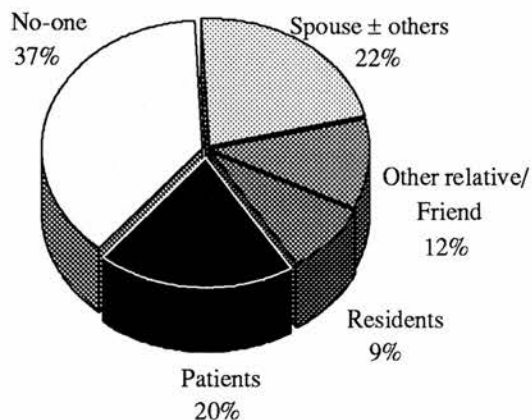
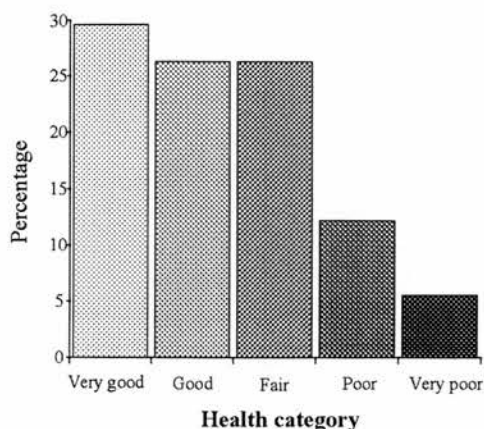


Figure 4.8 Co-residents



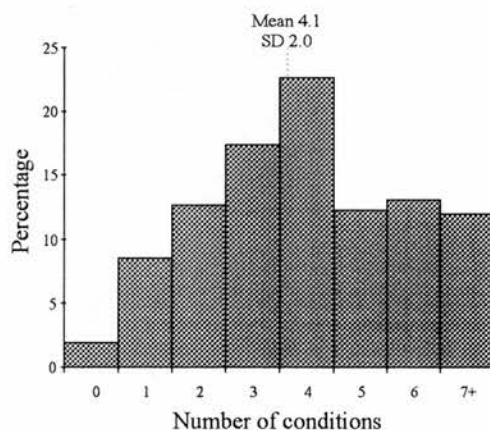
**Figure 4.9** General health status

Sixty seven percent of the falls causing the hip fracture occurred inside the patient's usual place of residence. The most common place of injury inside was the bedroom where 32% of the fractures occurred. The next most frequent site was the living room. Only four and five percent of the fractures were sustained on stairs or in the bathroom respectively, which might have been expected to be higher risk areas.

Twenty eight percent of the fractures occurred between 6 a.m. and midday. Forty percent were sustained between midday and 6 p.m. with a further 19% occurring over the next six hours.

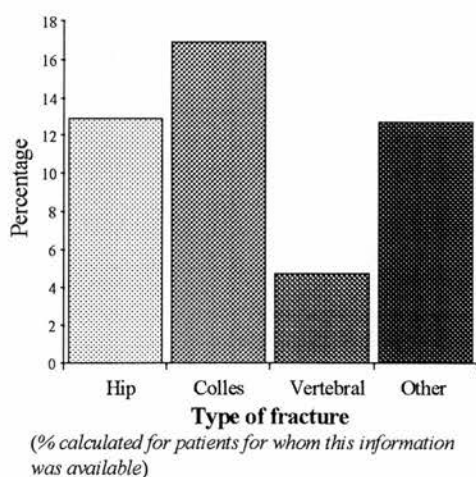
#### 4.4.3 Physical Health

The distribution of the general health categories for the whole study are given in Figure 4.9. The IRG had poorer general health than the SRG on the average as would have been anticipated. Thirty seven percent of the SRG rated their health as being very good



**Figure 4.10** Number of medical conditions

whilst only 17% of the IRG were rated at the same level.



**Figure 4.11** Type of previous fracture(s)

An average number of 4.1 (SD 2.0) medical conditions for the whole study population was obtained through a combination of self or informant report and a review of the medical records. See Figure 4.10. The medical

conditions were also categorised to be more meaningful to an elderly population. See section 3.5.1. for further details. The overall study average was 2.9 (SD 1.3). Thirty eight percent of the study population had a cardiac condition reported. The next most common condition was arthritis which attained a 30% prevalence in the study group. Not far behind was impaired visual acuity. Sciatica and hypertension then followed with approximately 20% of individuals having these reported. The average number of medications reported was 2.7 (SD 2.1). 38% of the study population had been hospitalised at least once in the year preceding their fracture.

A higher proportion of the IRG were underweight than was the case in the SRG with their respective percentages being 59 and 35. Speech impairment was also more common in the IRG with 14% having some impairment compared to 2% in the SRG. Visual acuity was classified as being normal in 72% of the whole study population and normal hearing in 80%.

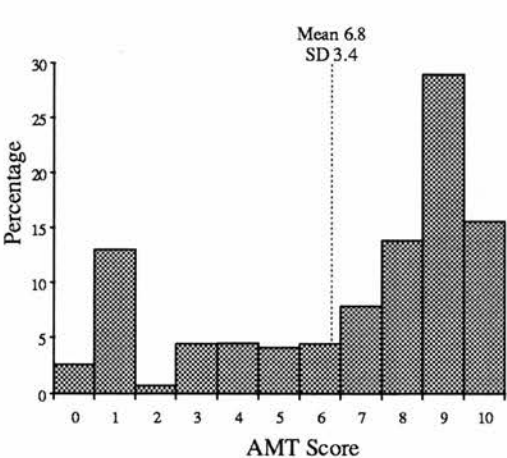
50% of the study population never smoked and 46% abstained from alcohol. These calculations do not include patients who were in nursing home or long stay hospital care. The data for patients in institutional care was recorded as being not applicable for smoking and alcohol consumption.

Overall 13% of the study population had previously sustained a hip fracture when the 15 patients for whom this information was not known were excluded. Ten percent of SRG had sustained a previous hip fracture and this was approximately doubled for the IRG when the 15 individuals for whom this data was not available were excluded. See Figure 4.11 for a summary of the previous fractures sustained for the whole study population. Underascertainment would have been a particular problem for vertebral fractures.

#### **4.4.4 Mental Health**

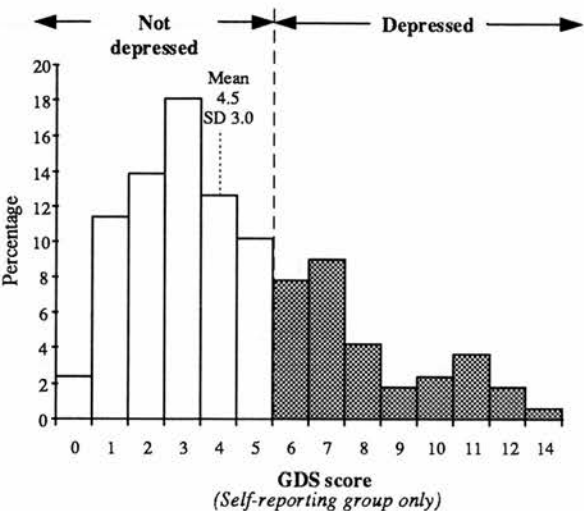
The overall Abbreviated Mental Test (AMT) score for the whole study was 6.8 with a standard deviation of 3.4 which clearly indicates marked variability in the distribution of

the scores throughout the study population, as shown in Figure 4.12. The largest single reason for allocating a patient to the IRG was the presence of dementia. Not surprisingly then over 80% of the IRG had an AMT score of less than seven indicating significant cognitive impairment. Five individuals, or 3%, of the SRG also had a score of less than seven. These patients did not have a



**Figure 4.12** Cognitive state

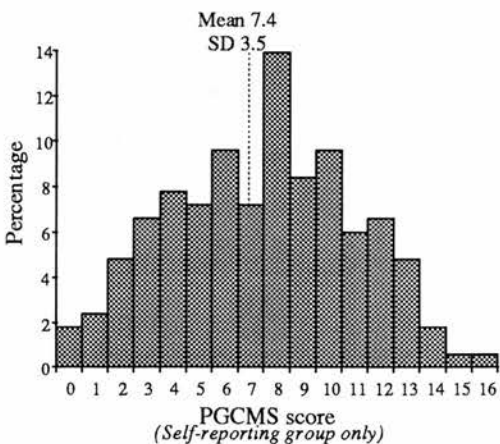
documented history of mental clouding prior to their hospitalisation and consequently were given the 'benefit of the doubt' with allowances being made for all the possible factors known to affect mental state after a hip fracture. With the benefit of hindsight these patients were misclassified as their mental state deteriorated over follow-up.



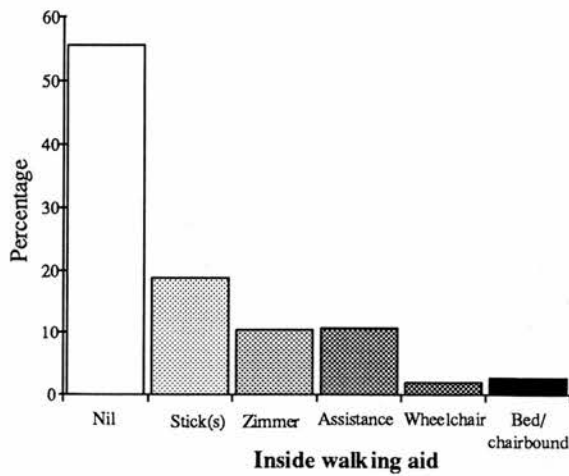
**Figure 4.13** Depression

Nearly a third of all the SRG of patients had scores suggestive of depression when the Geriatric Depression Scale (GDS) was administered shortly after their admission. A score of more than five is taken to be indicative of depression. See Figure 4.13

Unlike the GDS the Philadelphia Geriatric Center Morale Scale (PGCMS) which measures the quality of life of the patient does not have any



**Figure 4.14** Quality of life



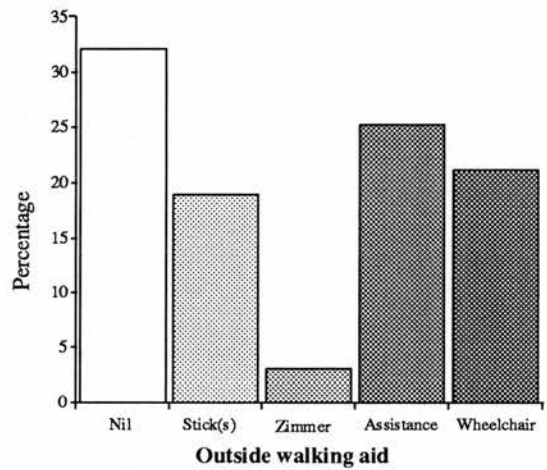
**Figure 4.15** Inside walking aid

#### 4.4.5 Mobility

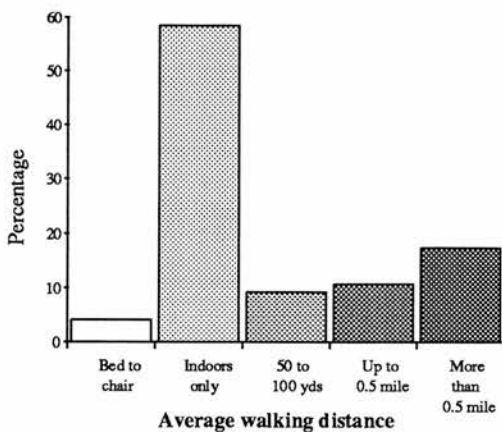
Mobility as gauged from the Barthel Index and the Clackmannan Scale subscores revealed that the hip fracture population had an impaired level of mobility prior to their fracture. The Barthel Index is known to suffer from a ceiling effect whereby fairly gross impairment has to be present before it is registered on the scale. Overall 86% of the

recognised cut-off points. The score can range from 0 to 17 with a higher score indicating a better quality of life. In the SRG an average score of 7 was obtained. See Figure 4.14.

Two thirds of the SRG at the time of their first interview were optimistic about regaining their pre-fracture level of mobility whilst 7% were not at all hopeful.



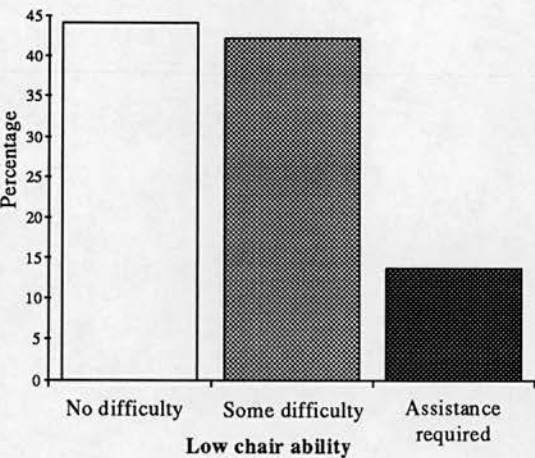
**Figure 4.16** Outside walking aid



**Figure 4.17** Average walking distance

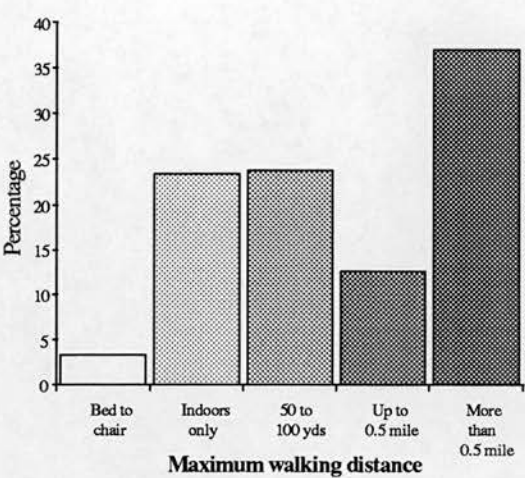
study population had a score of 6 or more which is indicative of good functioning. 94% of the SRG attained this score whilst 72% of the IRG achieved this. The Clackmannan Scale is a more sensitive index for detecting mobility impairment and this was indicated by the better spread of mobility scores between the different categories. The distribution was nonetheless still non-normal. There were three times as many of the SRG in the best mobility category

compared to the lowest category. For the IRG the reverse picture was seen with approximately four times the number in the poorest category compared to the best. No recognised cut-off points are available for the two subscales, as was the case for the PGCMS, making their interpretation in absolute terms more difficult.



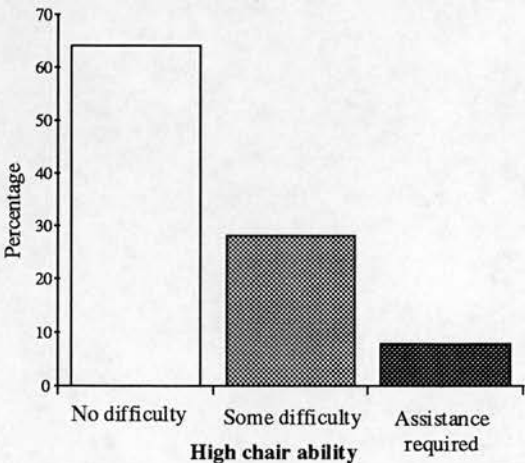
**Figure 4.19** Low chair ability

Figures 4.17 and 4.18 respectively indicate impaired walking ability. The hip fracture patients also had difficulty getting out of a chair prior to their fracture with this being more marked for a low chair than a high chair, as would be expected. See Figures 4.19 and 4.20. Around a third of the study population had no medical condition limiting their mobility prior to their fracture while approximately a half had one condition.



**Figure 4.18** Maximum walking distance

The impaired mobility of the hip fracture population prior to their fracture is made explicit in Figures 4.15 and 4.16 with this being most evident for the latter. Only 56% of the patients could walk inside without a walking aid whilst only 32% could do so outside. Similarly the average and maximum walking distances summarised in



**Figure 4.20** High chair ability



4.4.6 Self-care

The Barthel self-care subscale score ranges from 0 to 12 with a higher score being indicative of better functioning. The average for the whole study population was 9.8 with a standard deviation of 2.9. The IRG had more problems with their self-care than did the SRG as would be anticipated and this was reflected in their mean Barthel scores of 7.7 and 11.1 respectively. The frequency distribution for the scores for the SRG was heavily skewed to the left revealing the ceiling effect of the Barthel Index. The Clackmannan Scale more clearly illustrated the impaired self-care of the hip fracture population as it is more sensitive in detecting impairment than the Barthel Index. Refer to Table 1 in Appendix 7 for the score distributions for the two scales.

4.4.7 Instrumental Activities of Daily Living

Instrumental activities of daily living assessment is based on what the person actually does rather than his/her potential ability. This meant that two thirds of the IRG were not assessable because of their residence in supported forms of accommodation. The average score, for the Clackmannan IADL subscale, for the SRG and the IRG were 5.3 and 9.1 respectively which indicates the poorer functioning of the IRG.

4.4.8 Dependency

The parameters used to measure dependency all reflected the frailty of the elderly hip

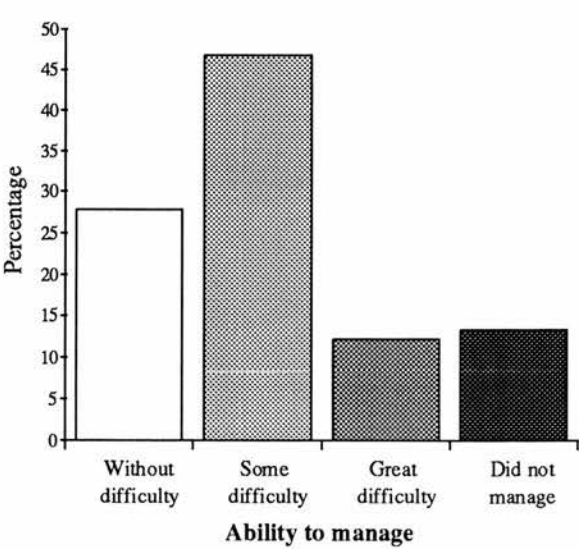


Figure 4.21 Ability to manage on a daily basis

fracture population being studied with this being especially evident for the IRG. Six percent of patients in the SRG classified themselves as not managing on a daily basis whilst 25% of the IRG were put into this category by their informants. Forty percent of the IRG were thought not to be able to manage on their own and 60% required help to plan their day. Almost a quarter of the IRG were classified as

being dependent using the total Barthel score, and of these, just under a third were totally dependent using the recommended cut-off point of 4 or less (RCP and BGS 1992). On the other hand only 4% of the SRG were dependent as gauged by their Barthel score and none were classified as being totally dependent. See Figure 4.22 for the distribution of the

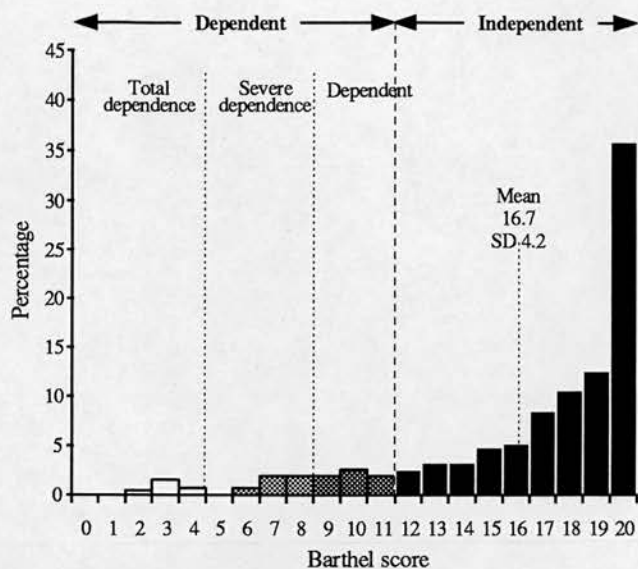


Figure 4.22 Dependency (Barthel Index)

Barthel Index scores for the whole study population. The ceiling effect of the Barthel Index is evident from this figure. The total Clackmannan Scale was however more sensitive in detecting dependency than the Barthel Index as shown by the distribution of its score in Figure 4.23.

Another indicator of dependency is the number of services required by people. If this is

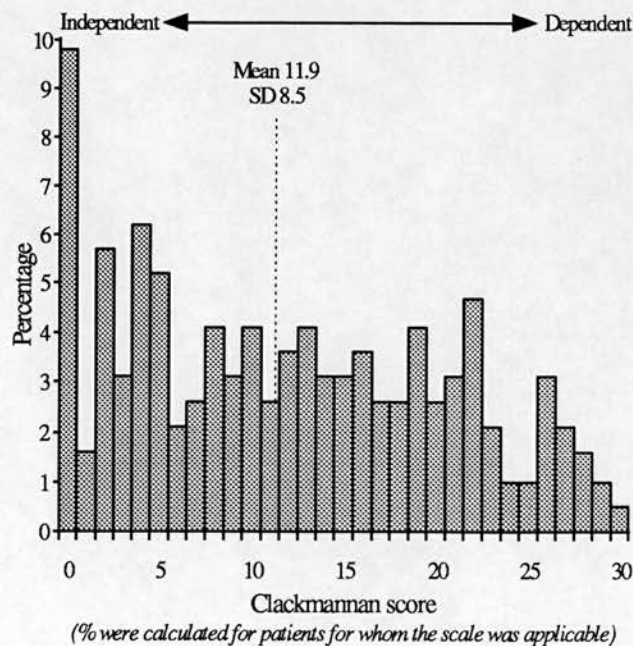


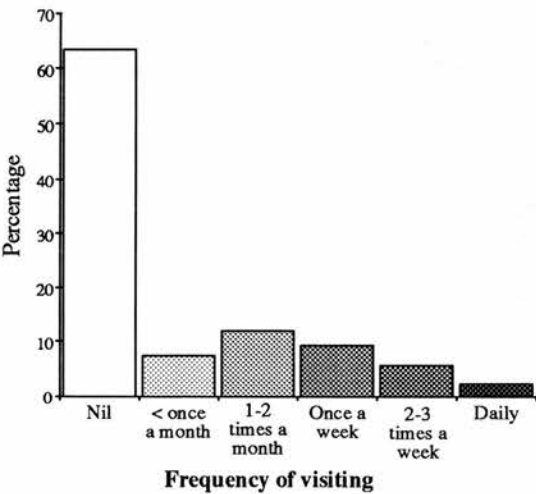
Figure 4.23 Dependency (Clackmannan Scale)

restricted to the study participants who were resident in their own homes or that of a relative or friend, thereby enabling the assessment of the dependency of ostensibly the fittest group in the study to be made, it is evident that these people did rely on community services prior to their fracture. See Figure 4.24. Only nine percent of people had not used a service in the three months prior to their fracture. The most

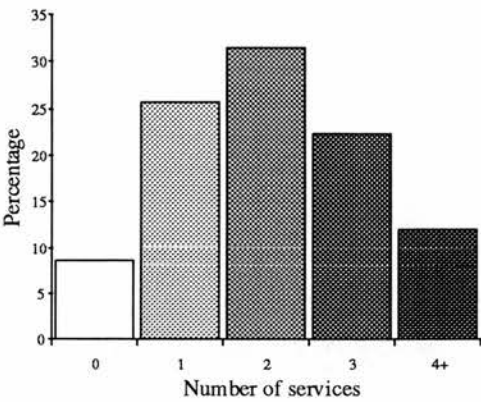
commonly used service was that provided by general practitioners followed by chiropodists and home helps with the percentages being 61%, 54% and 40% respectively.

### 4.4.9 Social

Twelve percent of patients had no contact with their relatives, 7% had no visitors, 24% did not see their neighbours, 74% did not visit anyone, 68% did not attend any social events and 74% did not attend church. The



**Figure 4.25** Frequency of patients visiting others



**Figure 4.24** Number of services

percentages for the last four variables were calculated for patients not in institutional care as they were not relevant for patients in this type of care. The limited frequency of patients visiting others is illustrated in Figure 4.25. The low pre-fracture frequency of visiting was attributable in part to the general frailty of the study population. Eighteen percent of the study population in non-residential accommodation kept a pet.

### 4.5 INTER-RELATIONSHIPS BETWEEN BASELINE VARIABLES

As mentioned in the introduction, the main purpose for investigating the inter-relationships between the baseline variables was to identify possible confounders for the multivariate analysis. Spearman's correlations were performed to investigate the relationships between the variables at a univariate level. Results of interest are presented in Appendix 9. A significance level of 1% was used to indicate a significant correlation in view of the large number of inter-relationships being tested.

#### **4.5.1 Whole Study Population**

Review of the demographic variables indicated that the variables age, accommodation and co-residents were broadly similar with respect to their significant relationships with other baseline variables. Accommodation and co-residents were the most comparable in their relationships as would be expected. All three were significantly associated with the total number of categorised medical conditions, the total AMT score, the self-care subscales, the total Barthel score as well with a number of the mobility parameters. Age was additionally significantly associated with weight, vision and hearing. Increased age was associated with a lower body mass, poorer vision and hearing. Accommodation and co-residents were significantly correlated with speech. It was interesting to note that sex only reached significance with age and that social class failed to have any significant correlations with any of the other baseline variables.

Measures of general physical health, namely self or informant rated health, the number of medical conditions, the number of categorised medical conditions and the number of hospitalisations in the year preceding the hip fracture were broadly comparable in their significant correlations. They were all related to each other as would be anticipated. However only the number of categorised medical conditions was associated with vision, hearing and speech. It was additionally related to the AMT score as was the number of medical conditions. Self or informant rated health and the number of medical conditions were related to the depression and morale scales. All of the general physical health variables were significantly related to the mobility, self-care, daily activity and dependency parameters excluding the 'help to plan day' variable. The only notable exceptions to this were the lack of a significant correlation between self or informant rated health and the ability to get out of either a high or low chair and the failure of the number of hospitalisations to attain significance with the total Barthel score or any of its subscales.

Speech attained a larger number of significant associations with other baseline variables compared to that observed for weight, vision, and hearing. The significant baseline associations for speech covered a broad range of domains.

It was interesting to note that a previous hip fracture was only significantly related to two mobility parameters these being the Clackmannan mobility sub-scale and the inside walking aid. Both relationships indicated poorer functioning if a previous fracture had been sustained as would be expected.

Mental status as gauged by the AMT score was significantly correlated with age, years of education, accommodation and co-residents. It was also related to the total and categorised number of medical conditions as well as weight and speech. The AMT score was correlated with most of the mobility parameters and all of the dependency measures as well as the frequency of visiting and fracture type.

The Geriatric Depression Scale score and the Philadelphia Geriatric Center Morale Scale score showed similar patterns of significant correlations to the AMT score. They were however additionally correlated with self or informant rated health and the 'frequency of visiting neighbours' but not with 'how the person managed on a daily basis' or 'whether they needed help to plan their day'.

All of the mobility parameters were associated with age, accommodation, co-residents, self or informant rated health and the mental, other mobility and dependency measures except the 'help to plan day' variable, and the social variable 'frequency of visiting'. There was no consistent relationship with weight, vision, hearing and speech. It should also be noted that the 'ability to get out of a high chair' and 'limitations in mobility' were not related to any of the mental parameters. The outside walking aid and average distance walked were also associated with frequency of contact with neighbours.

The dependency variables 'how the individual managed on their own' and the total Barthel and Clackmannan scores showed a broad range of significant correlations with other baseline variables. These included age, accommodation, the general physical and mental health variables, mobility, and on the social side the frequency of visits from neighbours.



The only social variable to show any number of significant correlations with another baseline variable was the number of relatives that the person was in contact with.

Despite the fact that many of the correlations presented in this section were significant, the majority of the associations were in fact only relatively weak as indicated by the magnitude of their Spearman's correlation coefficient. Pre-fracture demographic, injury and social variables mainly had weak correlations with the other baseline variables. Variables in the physical health, mobility, self-care and dependency domains all attained the highest correlations most consistently with other variables in their particular domain. The majority of the self-care variables were moderately correlated with each other, the mobility variables were moderately to strongly correlated with other mobility variables, and the majority of the dependency variables were strongly correlated with each other. Strong associations were also noted for dependency and the self-care variables. Similar strengths and patterns of association for the correlations for the baseline variables for both the SRG and IRG of patients were observed and will not be detailed in the following sections.

#### **4.5.2 Self-reporting Group**

The number of significant correlations obtained with the baseline variables for the SRG were fewer than that for the whole study. This may be due to reduced power because of smaller numbers and in addition, the range of some variables may be narrower, also tending to reduce the power. The baseline variables for which this was most evident were age, accommodation, the general health parameters and mental state. For most of the patient mobility measures, the variables accommodation, co-residents, speech, mental state, limitations in mobility and how the person managed on a daily basis were not significantly correlated with them. This contrasts with the comparable correlations for the whole study population. Similarly the variables speech, mental state, 'how the patient managed on a daily basis' and 'whether they needed help to plan their day' were not significantly correlated with the dependency parameters for the SRG in contrast to the results for the whole study population. For the social variable 'frequency of contact with relatives' few significant correlations were obtained for the SRG but a number were attained mainly for dependency parameters for the whole study. A different picture was



however obtained for two other social variables, namely 'frequency of visiting others' and 'frequency of contact with neighbours'. Significant relationships for 'frequency of visiting others' and all of the mental state and most of the mobility and dependency measures were observed for the SRG but not for the total sample. A similar but more restricted range of correlations were obtained for the 'frequency of contact with neighbours'.

#### **4.5.3 Informant-requiring Group**

As for the SRG of patients fewer significant correlations were obtained amongst the baseline variables for the IRG compared to the whole study group. No significant associations were obtained with age for the IRG. A restricted range of correlations for accommodation and co-residents were observed but the mobility correlations were comparable with the whole study group. Apart from the informant rated health for the IRG the other general health parameters namely the number of medical conditions, 'the total number of categorised medical conditions', 'number of hospital admissions in the year preceding the hip fracture' and speech, had a reduced number of significant correlations which was most marked for the mobility and dependency parameters compared to the whole study. The AMT score was only correlated with accommodation, co-residents and speech for the IRG, whilst for the whole study group it was significantly associated with a broad spectrum of variables. The mobility variables were significantly correlated with one another as was also the case for the whole study group. There were far fewer associations with the variable limitations in mobility for the IRG. A broadly similar pattern of significant associations was observed for the dependency measures. The variables 'whether the person managed on their own' and 'whether they needed help to plan their day' showed fewer associations for the IRG in all of the major domains. Only a limited number of significant correlations were obtained for the baseline social variables for the IRG. A number of associations were however observed for the variables 'number of relatives in contact with', 'frequency of visitors' and 'frequency of neighbours'.

#### **4.5.4 Summary of Inter-relationships**

The variables within particular domains showed broadly similar significant correlations with other baseline variables as would be expected. Key variables within each domain

correlated with most of the other main variables in the other domains. The only exception to this were the social variables which yielded only a limited number of significant associations with other baseline variables. Fewer significant correlations were obtained for the SR and IRGs individually, this being more pronounced for the latter. It was specifically interesting to note that in the IRG age did not have any significant associations with other baseline variables. Also few social variables achieved significant relationships and this in part may be attributable to the much fewer number of individuals for whom these variables were applicable.

Whilst a large number of significant correlations were obtained with the baseline variables the actual strength of the association for the majority of the relationships were however weak. Notable exceptions were : the self-care variables which yielded correlations of moderate strength with each other; mobility variables which were moderately to strongly correlated with each other; and the dependency variables with majority attaining strong associations with other dependency variables and the self-care variables.

#### **4.6 FOLLOW-UP DATA**

The results for this section are mainly summarised in graphical form using two approaches. Firstly, the results will be presented with 'deceased' as an outcome category at each stage of the follow-up so that the impact of the hip fractures at the population level can be gauged. Secondly, only the patients who survived to one year post-fracture will be reviewed so that the impact of the hip fracture may be assessed more clearly at the individual level. It was necessary to present the data in this dual fashion because a higher proportion of patients may be dependent one year post-fracture than was the case pre-fracture, but this may be masked at a population level because of the death of the frailer individuals at the outset of the study during the period of follow-up. The raw follow-up data is given in tabular form in Appendix 7. These tables do not include deceased patients as an outcome and consequently the percentages for the population approach differ from what is presented in the graphs.

4.6.1 Demographic

Nineteen people died within the first month of their fracture which represented 7 percent of the study population. The corresponding numbers for the six and twelve months follow-up interviews were 53 (20%) and 77 (29%) respectively. The survival curve was given in Figure 4.3. It should be

noted that the four medical exclusions made during the course of the follow-up, due to the individual sustaining a significant medical event that significantly interfered with the assessment of the outcome from their hip fracture, were all known to be alive at the end of the one year follow-up period and consequently were included in the mortality calculations. They were not however included for the other outcome variables of interest.

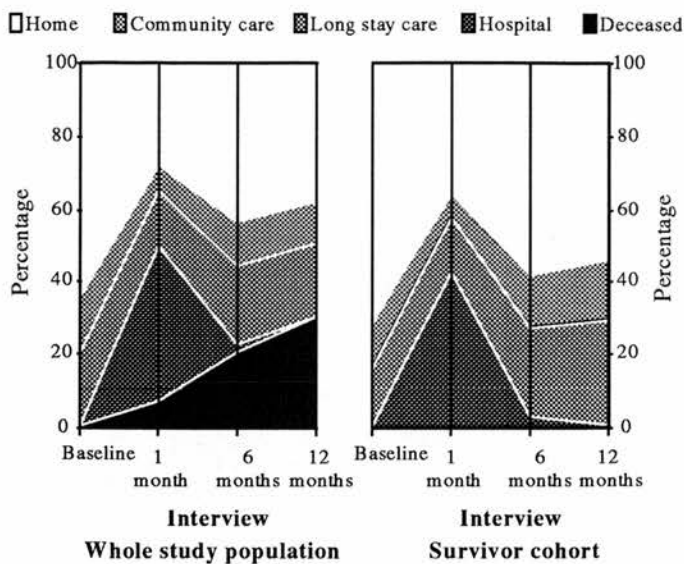


Figure 4.26 Secular changes in accommodation

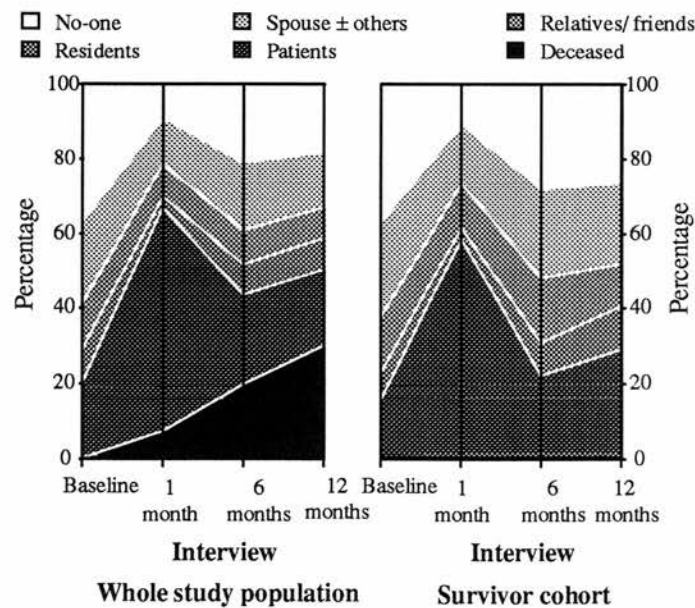


Figure 4.27 Secular changes in co-residents

The average age of survivors at the time of their fracture was 1.2 years younger than that for the study population as a whole. There was no sex differential in survival with just under 70% of both men and women surviving to one year of follow-up but women were significantly older than men. Single people had a higher mortality than married

or widowed people over the period of follow-up. The respective percentages were 38, 23 and 33 and this is largely attributable to their higher average age.

Just under three fifths of people living in their own homes prior to their fracture were still resident there one year later with this figure rising to just over three quarters when survivors only were considered. Slightly smaller proportions were observed when only people who were able to live by themselves in their own homes prior to their fracture were reviewed. The figures were just under a half and approximately seven tenths for the whole study and survivors respectively.

The movement of the hip fracture population into more dependent forms of accommodation over the 12 month follow-up period is clearly illustrated in Figure 4.26. In the survivor cohort the number of people in institutional care almost doubled reflecting their increased dependency following their hip fracture. It should be noted however that the total number of people in institutional care did not change over the year of follow-up due to the frailer individuals in the study dying with the number of patients being 54. Refer to Table 4 in Appendix 7. The data for co-residents mirrors the changes for accommodation as would be expected and this is summarised in Figure 4.27.

4.6.2 Physical Health

The categorical variable 'self or informant rated health' showed a distribution skewed towards the worse end of the spectrum. It was interesting to note that the number of people with poor or very poor health ratings halved over the year of follow-up as the frailer individuals died the numbers being 48 and 23 respectively.

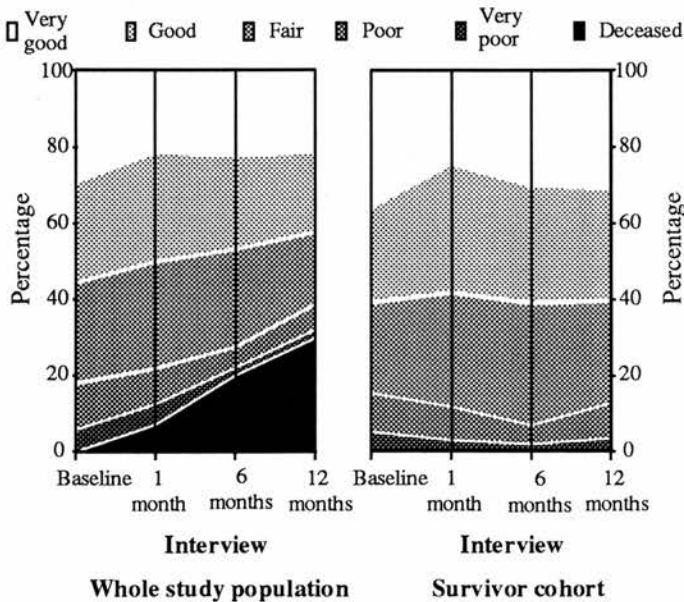


Figure 4.28 Secular changes in general health

Refer to Figure 4.28. Looking specifically at the survivor cohort it can be seen that there was little change in health status over the year of follow-up.

#### **4.6.3 Mental Health**

In the EHFS a conservative cut-off point of seven was used for the AMT score to indicate significant mental clouding. Using this definition just under a fifth of the IRG and all but five of the SRG scored seven or more on the AMT at baseline. The mean AMT score showed little change throughout the study and showed a fairly consistent pattern for both the SRG and the IRG for the whole study population and the survivor cohort. Refer to Tables 4.4 and 4.5.

Using a cut-off point of six or more for the Geriatric Depression Scale 31% of patients in the SRG were categorised as being depressed at their initial interview. This rose to 39% at one month then fluctuated slightly to 35% and 37% at 12 months in the patients for whom this data was available. The corresponding percentages for the survivor cohort were 31, 37, 35 and 37 respectively. There was little variation in the mean score over the study period as shown in Tables 4.4 and 4.5. The Philadelphia Geriatric Center Morale Scale score also remained fairly stable over the study period for both the whole study population and the survivor cohort. Refer to Tables 4.4 and 4.5.

The percentage of patients in the survivor cohort of the SRG who very optimistic about regaining their previous level of walking was 51% at baseline and 59%, 42% and 24% for the one, six and 12 month interviews respectively. These percentages are calculated for patients in whom this data was available. At six months post-fracture only 10 (8%) patients had regained their pre-fracture level of mobility and a further five (10%) patients achieved this six months later. These patients were not included in the 'optimism about mobility' calculations.

Table 4.4 Secular changes in continuous variables for self-reporting group

RESEARCH INSTRUMENT	INTERVIEW Mean (SD)				
	Baseline	One month	Change from baseline	Six months	Change from baseline
Abbreviated Mental Test score	7.2(3.3)	-	-	7.7(3.1)	0.5(1.8)
					7.5(3.3)
					0.2(1.8)
Geriatric Depression Scale score	4.4(3.0)	5.1(3.4)	0.7(2.5)	4.8(3.1)	0.4(2.4)
					5.0(3.3)
					0.6(2.7)
Philadelphia Geriatric Center Morale Scale score	7.3(3.6)	6.7(3.9)	-0.5(3.1)	6.6(4.0)	-0.7(3.3)
					6.7(4.2)
					-0.6(3.5)
Barthel Index score	17.3(3.8)	14.6(5.2)	-2.7(3.5)	15.7(4.9)	-1.6(3.0)
					15.0(5.7)
					-2.3(3.8)
Clackmannan Scale score	11.2(8.5)	17.5(5.2)	9.8(5.8)	14.9(7.6)	5.3(5.3)
					15.4(7.3)
					6.2(5.2)



Table 4.5 Secular changes in continuous variables for whole study population

RESEARCH INSTRUMENT	INTERVIEW Mean (SD)				
	Baseline	One month	Change from baseline	Six months	Change from baseline
Abbreviated Mental Test score	6.8(3.4)	-	-	7.6(3.1)	0.5(1.8)
				7.5(3.3)	0.2(1.8)
Geriatric Depression Scale score	4.5(3.0)	5.2(3.3)	0.7(2.5)	4.9(3.2)	0.4(2.5)
				5.0(3.3)	0.6(2.7)
Philadelphia Geriatric Center Morale Scale score	7.4(3.5)	6.9(3.8)	-0.6(3.1)	6.6(3.9)	-0.8(3.3)
				6.7(4.2)	-0.6(3.5)
Barthel Index score	16.7(4.2)	13.8(5.5)	-3.1(3.8)	15.3(5.0)	-1.8(3.1)
				15.0(5.7)	-2.3(3.8)
Clackmannan Scale score	11.9(8.5)	17.9(5.3)	9.4(6.2)	15.1(7.4)	5.3(5.3)
				15.4(7.3)	6.2(5.2)

4.6.4 Mobility

A general pattern for the secular changes in mobility emerged over the year following the hip fracture. Firstly there was a marked decline in mobility at one month post-fracture as

would be anticipated. This was then followed by partial improvement at six months and then there was a plateauing out of any further improvement between six and 12 months post-fracture.

The IRG started from a poorer functional baseline, were affected more profoundly and made a less complete recovery than the SRG.

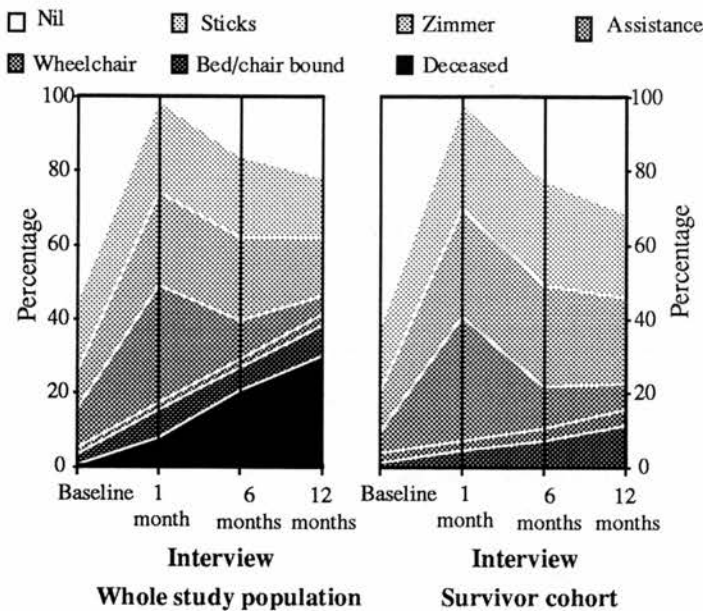


Figure 4.29 Secular changes in inside walking aid

The effect of the hip fracture on mobility can readily be seen by the changes in the Barthel and the Clackmannan

mobility subscale scores over the year of follow-up shown in Table 4 of Appendix 7. Figures 4.29 and 4.30 show the changes in the type of walking aid required. The dependence on outside walking aids showed the most change. It should be noted that outside walking ability at one month post-fracture was not documented

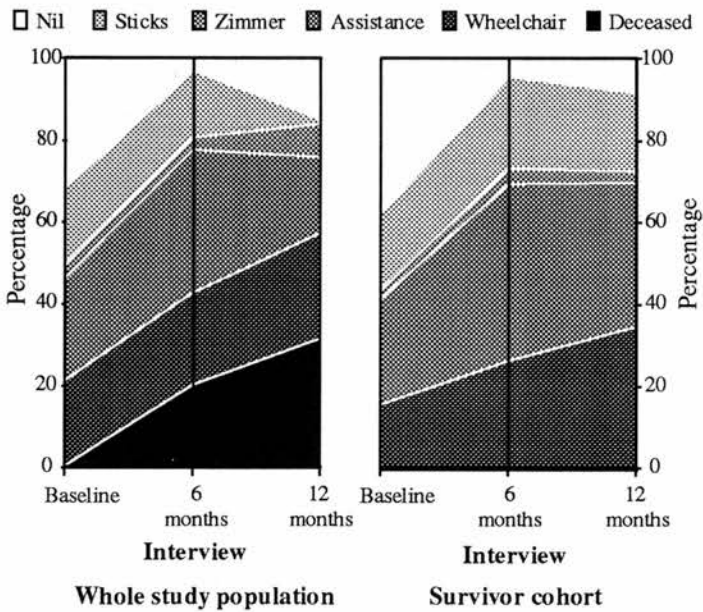
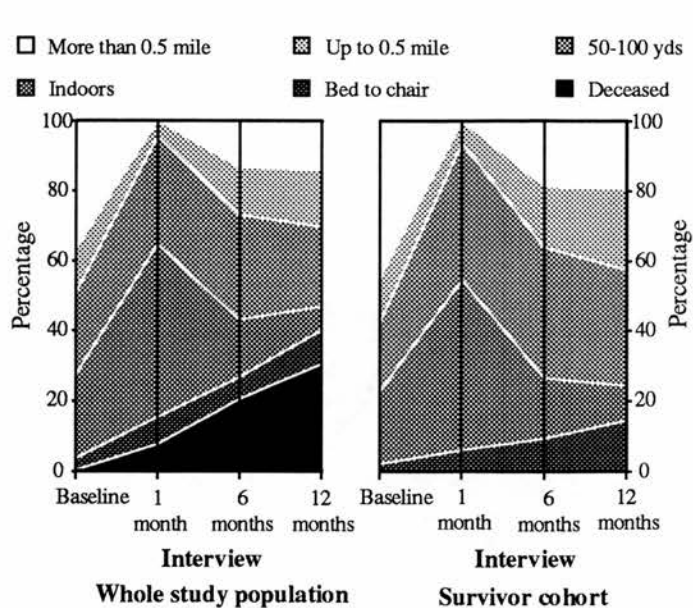


Figure 4.30 Secular changes in outside walking aid



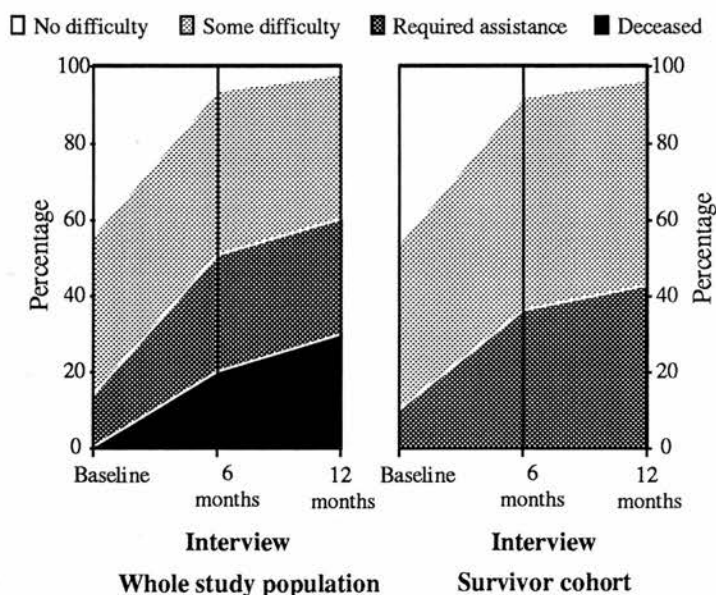
**Figure 4.31** Secular changes in maximum walking distance

because it was anticipated that few, if any, of the patients would have been able to walk outside at this relatively early stage of their rehabilitation. The impact of the hip fracture on subsequent mobility can also be seen in Figure 4.31 which portrays the secular changes for the maximum walking distance.

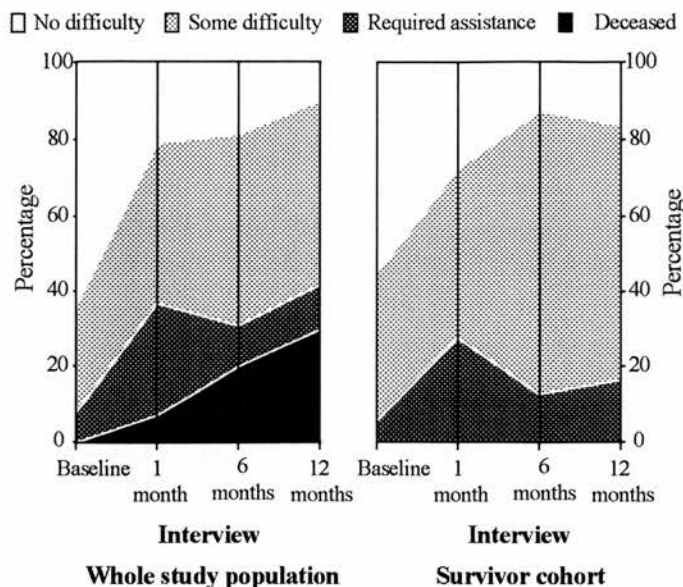
A further indicator of mobility problems which arose as a consequence of the hip fracture was the difficulty encountered when trying to get out of a chair. The proportional change was greater for a low chair than a high one as would be expected. See Figures 4.32 and 4.33.

#### 4.6.5 Hip Function

Hip function was assessed at six and 12 months post-fracture using the Harris Scale. This section will begin with a review of the total Harris score results before presenting the results of its individual components. The hip pain results are given in section 4.6.6 as it was an important outcome measure in its own right. The



**Figure 4.32** Secular changes in ability to get out of a low chair



**Figure 4.33** Secular changes in ability to get out of a high chair

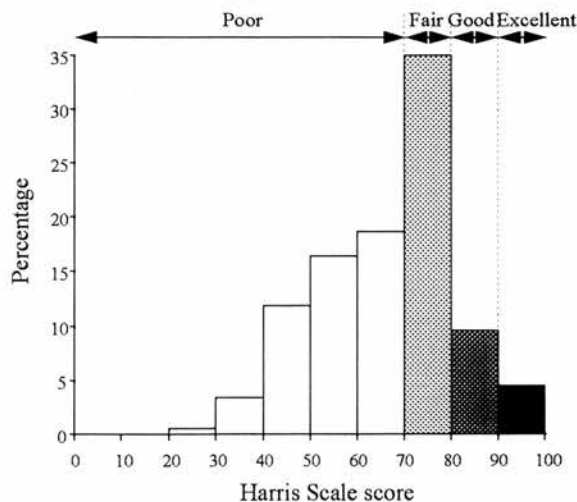
survivor cohort was very comparable and consequently was not also presented. The figures clearly show that little change was observed in hip function over the final six months of follow-up.

Only 10 (5%) patients at six months post-fracture could walk one mile or more without any form of walking aid and this increased by a further three patients over the next six months in the survivor cohort. At the other end of the spectrum 144 (77%) of the survivor cohort required more than two sticks to walk this distance at six months and 157 (84%) at one year post-fracture representing some deterioration in function.

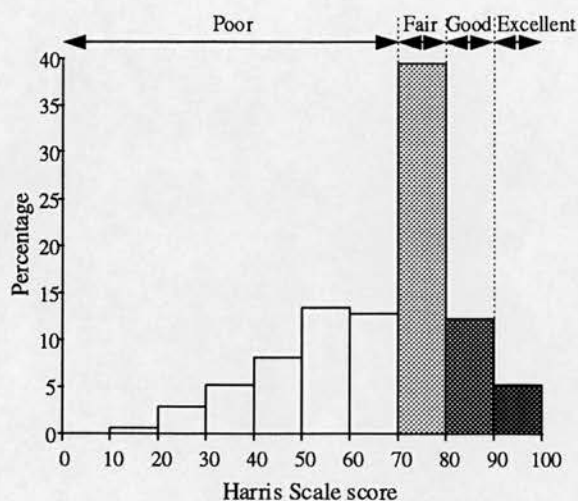
Between six and 12 months of follow-up there was a modest decline in walking gait. Forty percent of patients in the survivor cohort could walk without a limp at six months post-fracture and this decreased to 36%. The proportion of patients with a severe limp rose from

maximum walking distance subscore results will similarly not be presented in this section as this parameter has already been discussed under the mobility subsection heading.

The distribution of the six and 12 month total Harris scores for the whole study population are given in Figures 4.34(a) and 4.34(b). The data for the



**Figure 4.34(a)** Hip function at six months



**Figure 4.34(b)** Hip function at 12 months

13% to 17% over the same time interval. Refer to Appendix 7.

The ability to sit comfortably in any chair rose over the final six months of follow-up from 70% to 79% in the survivor cohort whilst the proportion who could not sit comfortably remained static at 2%.

Twenty six percent of the patients could not manage stairs at all at one year post-fracture representing a 5% increase since the six month assessment. Baseline data on stair climbing ability was obtainable from the Barthel Index and this revealed that in the survivor cohort there was in fact a 15% increase in the number of patients who could not manage stairs at all over the one year period, indicating a substantial decline in functioning.

Another component of the Harris scale is the ability of an individual to put on their shoes and socks or stockings. At one year post-fracture only 30% of the study population were able to perform this task without any difficulty and 40% required help to do this. The corresponding proportions at six months were 34% and 36%. It should be noted that the ability to put on one's shoes and socks or stockings also forms part of the Barthel Index and a comparison with the pre-fracture level of functioning was therefore possible. At baseline 49% of the survivor cohort were able to perform the task without difficulty and this indicates that there had been an 18% reduction over the year following the hip fracture. The percentage of patients who needed assistance to perform this task rose by the same amount over the year of follow-up.

A degree of shortening of more than one inch was noted for 12% of the whole study population at the 12 month interview. A fixed flexion deformity was seen in four individuals at one year post-fracture and all occurred in patients who required an informant.

4.6.6. Hip Pain

The hip pain categories at the six and 12 month interviews are given in Figures 4.35(a) and 4.35(b). It can be seen that the distribution of scores is asymmetrical at both time points and that there was little change in the hip pain distributions over the six month interval. At 12 months post-fracture only one patient (0.5%) had severe pain at rest and 103 (55%) had no hip pain.

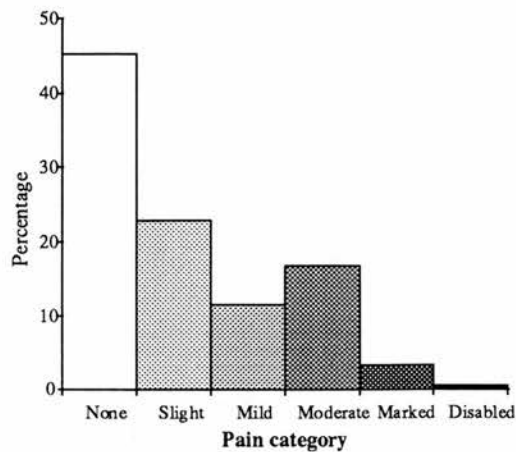


Figure 4.35(a) Hip pain at six months

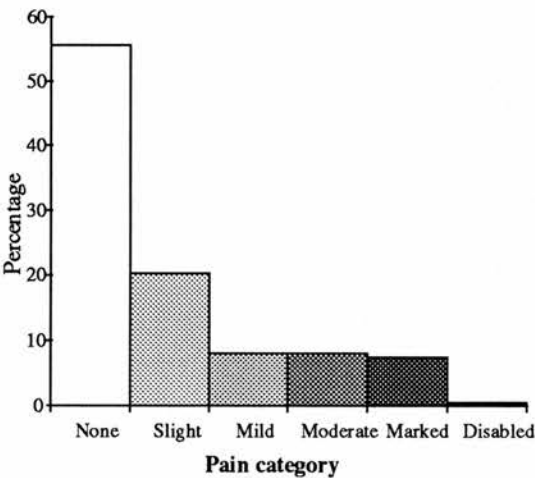


Figure 4.35(b) Hip pain at 12 months

4.6.7 Self-care

The pattern of change over the one year follow-up period for the Barthel and Clackmannan self-care subscales was similar to that seen in their mobility subscales. At one month post-fracture there was a marked decline in function followed by some improvement at six months. However unlike the mobility sub-scale scores, the self-care subscale scores

deteriorated further over the following six months for all groups but were nonetheless still better than the one month post-fracture levels. Refer to Table 4 of Appendix 7. The self-care subscales, like their mobility counterparts, indicated that the IRG started from a poorer baseline than the SRG in their self-care, were more affected and made a poorer recovery.

4.6.8 Instrumental Activities of Daily Living

The series of Clackmannan daily activity subscale scores over the study period showed a similar pattern to the mobility and self-care Clackmannan subscales. Refer to Table 4 of Appendix 7.



4.6.9 Dependency

The proportion of people who were classified as managing without difficulty on a daily basis declined by half over the 12 month study period with the percentages changing from 28 to 16 respectively. The number of patients who were stated not to manage at all actually declined over the year of follow-up and this was due to the frailer individuals dying. See Figure 4.36.

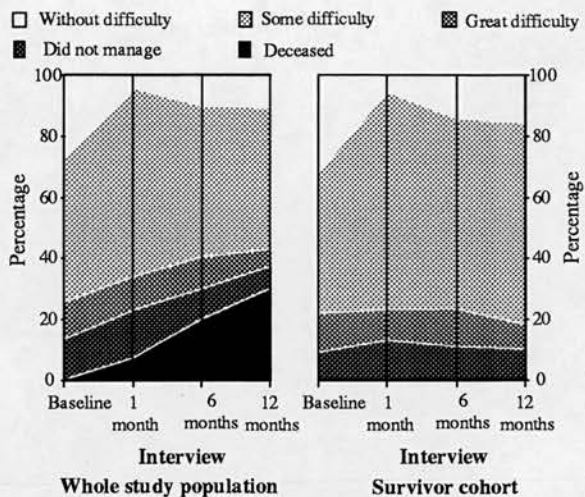


Figure 4.36 Secular changes in ability to manage on a daily basis

The total Barthel score and the total Clackmannan score showed similar changes to their individual subscales over the 12 months of follow-up as would be anticipated and as a consequence will not be redescribed here. The average values for the Barthel Index and the Clackmannan Scale for each of the four interviews for both the whole study population and the survivor cohort are given in Tables 4.4 and 4.5 respectively. The increase in dependency over the year of follow-up as gauged by the total Barthel score is shown in Figure 4.37. Given that the Barthel Index only detects gross impairment the observed changes in dependency are important.

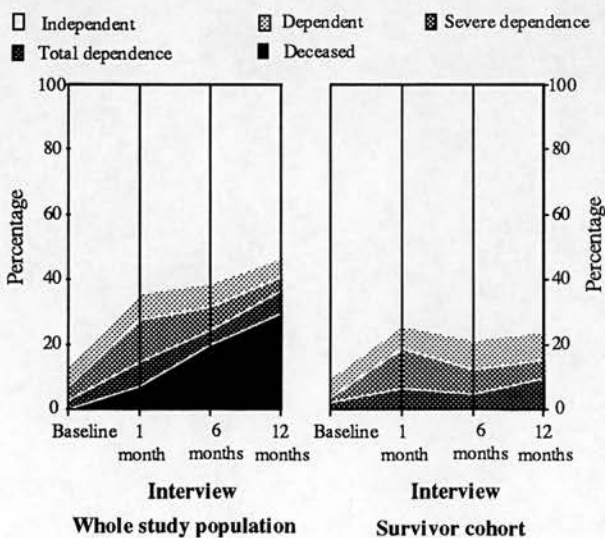


Figure 4.37 Secular changes in dependency

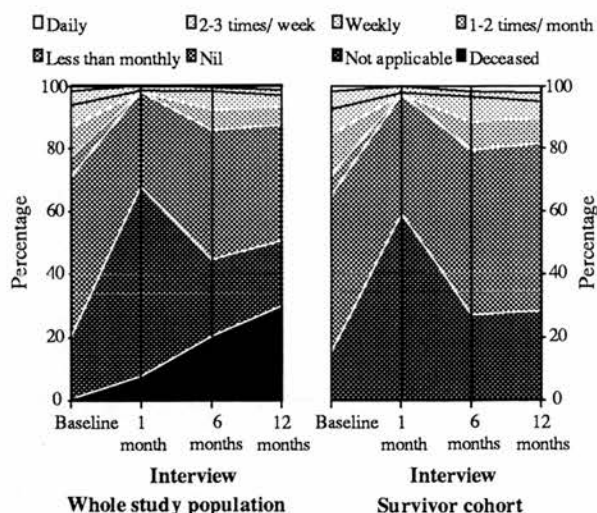
Another measure of dependency is the number of health and social services required. This was looked at for individuals who were resident in their own homes or that of a relative or friend. It was decided not to include people from sheltered housing on the basis that the services provided in this type of care could be quite extensive, and could include meal provision and

dressing assistance for example by the warden. An average of 2.1 services were used. At one month there was a decrease in the average number of services required by individuals who had been discharged back into the community at this stage. This is presumably a direct result of the fitter patients being discharged at an earlier stage. The number of services was not calculated for those individuals still in institutional care. Over the 12 month period the increased dependency on services was evident in the survivor cohort with an average of 2.9 services being required compared to 2.0 at baseline.

The most extensively used health or social service by the whole study population was that provided by general practitioners, with 60% of the study participants having seen their doctor at least once in the three months preceding their hip fracture where this was applicable. The next most utilised services was that provided by chiropodists and home helps, the percentages being 51 and 40 respectively. The time intervals for which service use was ascertained was different for the various interview schedules. At the baseline interview the period assessed was the three months prior to the interview, for the one month interview it was the preceding two weeks, and for the six and 12 month interviews it was the previous month. This accounts for some of the apparent decrease in usage for some of the services, such as the general practitioner and chiropodist for example, in the last two interviews. This is compounded by the less fit individuals moving into more dependent forms of accommodation where the provision of community-based health and social services may no longer be necessary. An example of this is the home help service. In the SR survivor group the number of individuals for whom this service was not applicable rose from eight at baseline to 26 a year later. Nonetheless the proportion of people who received this service and for whom this service was still relevant increased between the baseline and twelve month interviews from 37% to 45% reflecting the increased dependency of these individuals who were still able to live in the community. For the whole study population the number of individuals who were actually receiving home help services changed from 77 at baseline to 52 one year after the hip fracture.

#### 4.6.10 Social

The restricted pre-fracture social interactions of the hip fracture population was exacerbated following their fracture. This was largely directly attributable to the effect of the hip fracture limiting the mobility of these patients. This is illustrated in Figure 4.38 for the variable 'frequency of visiting others' and is most apparent for the survivor cohort. Social contact which was not so reliant on the patient's mobility such as contact with neighbours or other people visiting the patient changed little over the study period.



**Figure 4.38** Secular changes in frequency of patient visiting others

## 4.7 DISCUSSION

The descriptive epidemiology results from the EHFS will be presented in the most appropriate way to enable comparisons with the literature to be made. No published study has presented their results in terms of a survivor cohort. As this form of presentation gives a clearer indication of the impact of the hip fracture at an individual level results from the survivor cohort in the EHFS will be used to illustrate important findings.

### 4.7.1 Inter-relationships Between Baseline Variables

A large number of the baseline variables attained statistically significant correlations with other baseline variables. The variables within each domain showed broadly comparable significant correlations with variables in other domains. The key variables in each domain also correlated with most of the other main variables in other domains. The only exception to this were the social variables and this may in part reflect the difficulty in assessing social health.

The strength of the association of the majority of the baseline correlations were however relatively weak as indicated by the magnitude of their correlation coefficient. As a result

of this, confounding should not be a major problem in the EHFS. The associations within the domains were in general stronger than the associations observed between the domains. Strong associations were however observed for the majority of the dependency variables both with each other and with the self-care variables. This means for example, that the significance of a dependency variable may be affected considerably by another dependency variable in the regression model. Also regression models with similar predictive power may be developed with any of the appropriate dependency variables in the model. The mobility variables were also noted to be moderately to strongly correlated with each other.

#### **4.7.2 Demographic**

The age distribution for the study population approximates that reported elsewhere with around half of the fractures occurring in people aged between 80 and 89 years (Swanson and Murdoch 1983, Greatorex 1988, Sernbo and Johnell 1993). Similarly the marked female predominance has been previously well documented in the literature with there being approximately four times as many women fracturing their hips as men (Furstenberg and Mezey 1988, Greatorex 1988, RCP 1989, Magaziner et al 1990, Ray et al 1990, Sernbo and Johnell 1993). The magnitude of the age- and sex-specific incidence rates for hip fracture in the EHFS are consistent with other studies in the literature and also showed that the age-specific incidence in women is twice that of men (Gallagher et al 1980, Boyce and Vessey 1985, Swanson and Murdoch 1983, Kreutzfeldt et al 1984, Jarnlo et al 1989, Bacon et al 1990, Kellie and Brody 1990).

The average age of women who fracture their hip has been documented to be higher than that of men. This is due to their increased longevity in conjunction with their higher age-specific incidence rates (Boyce and Vessey 1985, RCP 1989). Sernbo and Johnell (1993) using an unselected series of patients noted that the average age for women was 4 years higher than that for men which was comparable to the results in the present study.

No information was available on the marital status of an unselected series of hip fracture patients in the literature as was also the case with social class. 1991 census data for individuals aged 60 years or older living in postcode sectors EH1 to EH17 inclusive

indicated that 13%, 51%, 32% and 4% were single, married, widowed and divorced respectively. The corresponding percentages for the EHFS patients were 21%, 24%, 53% and 2%. These data clearly indicate that a much higher proportion of patients in the EHFS were widowed than in the general Edinburgh population aged 60 years or over. A contributing factor was the much higher average age of the EHFS population. 62% of the EHFS were aged 80 years or over whilst only 17% of the Edinburgh population aged 60 or more was in this age range.

Many of the hip fracture studies used a selected population with the majority restricting themselves to individuals who were resident in the community prior to their fracture. This limited the comparisons that could be made for the current study regarding the pre-fracture place of residence. Furthermore those studies which used an unselected population were often performed in other countries whose different forms of supported accommodation are not directly comparable with those in Britain. Reviewing 1991 census data for Edinburgh residents, in postcode sectors EH1 to EH17 inclusive, for people of pensionable age the proportions who were in sheltered housing, residential care, nursing homes and long stay care hospitals were 1.1%, 0.9%, 1.2% and 1.7% respectively. The corresponding percentages in the EHFS were 6.3, 8.9, 8.5 and 11.5. Standardising for age and sex using the census data it would have been expected to have had 8, 6, 11, and 10 patients in sheltered housing, residential care, nursing homes and long stay care hospitals respectively in the EHFS. The corresponding observed numbers were 17, 24, 23 and 31 which are clearly much higher indicating the greater frailty of the EHFS population compared to a comparable age and sex standardised population.

More extensive information is available for whether or not patients were living on their own, as this has been demonstrated to be an important prognostic factor for rehabilitation (Ceder et al 1980, Broos et al 1988). Greatorex (1988) in his English study noted that 42% of his study population lived alone prior to their fracture which was comparable to the 37% found in the current study. Sernbo and Johnell (1993) in their Swedish study investigating an unselected series of hip fracture patients reported that 62% of their study population lived alone in their own homes at the time of their fracture. The Swedish hip



fracture population was only three years younger than the average age in the current study so the differences in co-residents is not likely to be due to age differences in the two study populations.

Reported mortality for hip fractures in the literature varies widely depending largely upon the criteria used for recruitment into the study. Inclusion criteria which have a direct bearing on the observed mortality rates include factors such as age, sex, place of residence and mental state. Additionally there have been many anaesthetic and operative advances over the last few decades resulting in improved survival so the time when the study was performed is another confounding factor in the interpretation of mortality figures. One month mortality has been reported from being 4% up to 19% (Riska 1970, Kuokkanen and Korkala 1992). At six months figures of 16% to 23% have been given (Elmerson 1988, Kuokkanen and Korkala 1992). One year post-fracture mortality figures have been published as ranging from 14% up to 36% (Gordon 1971, Kenzora et al 1984). For the current study the one, six and 12 months mortality percentages were observed to be 7, 20 and 29. It should be noted that these figures under-represent the true mortality of the osteoporotic hip fracture population because the moribund patient were ineligible for the study. These figures compare closely to those found by Kuokkanen and Korkala in 1992 being 4%, 23% and 33% for one, six and 12 months post-fracture. This study had the most similar study population reported in the literature to the current study. The average ages in the two studies were 78 and 79 years respectively even though the study by Kuokkanen and Korkala (1992) included patients as young as 48 years old in their study. No exclusions however were made in the study by Kuokkanen and Korkala (1992). If the 17 moribund patients in the current study were included in the one month mortality calculations then this would have yielded a mortality of 13% which is over three times that observed by Kuokkanen and Korkala (1992) at the same stage. Assuming that the six patients in the present study whose hips fractured as a result of weakening due to a metastatic cancer deposit had also died by one year post-fracture then the overall mortality in the current study would have been 33% which is identical to that observed by Kuokkanen and Korkala (1992). The studies reporting mortality for unselected series of



hip fracture patients in the literature have not excluded moribund patients. The studies however that used selected populations did exclude moribund patients.

Figure 4.3 shows the observed mortality in the EHFS compared to the expected mortality adjusted for age and sex. A clear excess of deaths is seen in the hip fracture population with the effect being most marked within the first two months of the hip fracture. Seventy seven patients died during the course of follow-up compared to an expected 30. The higher death rate within the first few months of the hip fracture has been noted elsewhere (Gordon 1971, Jensen and Tondevold 1979, Dahl 1980, Kenzora et al 1984, Parker and Anand 1991). Several studies have reported that the excess deaths only occur in the first year of the fracture with the observed and expected survival curves becoming parallel after this time interval (Gordon 1971, Kenzora et al 1984, White et al 1987, Elmerston et al 1988, Parker and Anand 1991).

A review of the literature revealed that only one study has reported the cause of death for an unselected series of hip fracture patients at one year post-fracture. In this study Parker and Anand (1991) observed an overall mortality of 37% in their 709 consecutively admitted hospital patients. Nine percent of these patients were considered to have died directly as a result of their hip fracture. A further 16% of the patients died from causes possibly related to their hip fracture whilst the other 12% of patients who died within one year were considered to have died from totally unrelated causes which were related to ageing. The exact causes of death were not published in the paper by Parker and Anand (1991). In the present study, using death certificate information, 4% of the study patients died as a direct result of their hip fracture. However it must be borne in mind that a reporting bias may exist using death certificates as the data source. This arises because many doctors are reluctant to put a hip fracture as the principal cause of death on a death certificate as it may result in an inquest being held with resulting distress for the relatives. The effect of this is to underascertain the cause of death directly due to a hip fracture (Pemberton 1988).

### 4.7.3 Injury

The ratio of extracapsular fractures to intracapsular fractures in hip fracture populations reported in the literature varies widely. Moore and Quinlan (1989) found only 12% of their patients sustained extracapsular fractures whilst at the other end of the spectrum Lizaur-Utrilla et al (1987) reported 74%. In the current study 52% of the patients had an extracapsular fracture and this is consistent with the 44% to 57% reported for studies conducted in either England or Scotland (Stewart 1955, Murray and Young 1957, Clark 1968, Dias et al 1987, Parker et al 1992). In the current study patients who sustained an extracapsular fracture were significantly older than patients with an intracapsular fracture and this confirms the findings by Alffram et al (1964) and Parker et al (1992). They were also noted to have poorer cognitive functioning in the present study. Other studies have also reported that extracapsular hip fracture patients are physiologically older when compared to patients with an intracapsular fracture (Lawton et al 1983, Dias et al 1987, Parker et al 1992). More concurrent medical illness, regular medication use, less mobility and a higher probability of returning to supported forms of accommodation have all been reported for extracapsular hip fracture patients.

In the EHFS seven patients, or 3% of the study population, reported spontaneous fractures. The majority of studies in the literature report a similar proportion (Clark 1968, Brocklehurst et al 1978, Evans et al 1979, Horiuchi et al 1988) but a figure as high as 11% has been reported (Dias et al 1987). A pathological weakness of the bone may often be identified in patients with spontaneous fractures. Four of the patients in the EHFS were on steroid therapy which is causally linked with osteoporosis. Horiuchi et al (1988) noted that all of their elderly patients who sustained a spontaneous fracture had osteoporosis.

Ninety six percent of the fractures in the EHFS were attributed to falls. Direct comparison of the causes of the fall with other studies in the literature was difficult due to the different fall classifications used and the use of selected series of patients in some of the studies. Nonetheless some limited comparisons will be made. Thirty four percent of the patients indicated that an external factor, such as an object on the floor, was responsible for their fall which is higher than the 25% reported by Brocklehurst et al (1978) but considerably

lower than the 63% found by Dias (1987). Thirty six percent of patients in the present study stated that an endogenous factor was the cause of their fall. Jarnlo and Thorngren (1993) reported a figure of 45% for endogenous causes for the fractures in their selected population. The patients in the latter study had to have good cognitive function to be eligible for the study. In the current study 20% of the falls were not classifiable either because the cause of the fall was not known by the patient or there was inadequate data. Jarnlo and Thorngren (1993) report that 11% of their patients did not know how they fell.

Just over three quarters of the fractures in the EHFS occurred inside which closely corresponded to the 78% reported by Dias (1987). Sixty eight percent of the SRG of patients in the EHFS sustained their fractures inside which was comparable to the 63% found by Jarnlo and Thorngren (1993) for their selected hip fracture population. Thirty nine percent of the SRG of patients in the EHFS who injured themselves inside did so in the living room, 23% in the bedroom with only 5% in the bathroom. These figures correspond closely to those reported by Clark (1968).

The majority of fractures in the EHFS occurred between 6 AM and 6 PM and this is in agreement with the findings by Lucht (1971) and Jarnlo and Thorngren (1993).

Factors that have been identified as being associated with an increased risk of falling have been summarised by Parker and Pryor (1993) to be : increased age, female, mental impairment, concurrent medical illness, previous stroke, visual abnormalities, undernourishment, physical disability, disorders of gait and balance, postural imbalance, not taking regular exercise, greater dependence on others, alcohol, multiple medications, tranquillisers and antihypertensives. It is outwith the scope of this thesis to investigate the specific factors associated with the mechanism and circumstances of the fall in the EHFS. The reader is referred to the review by the Kellogg International Work Group on the Prevention of Falls by the Elderly in the Danish Medical Bulletin (1987) for an excellent overview on falls.

#### 4.7.4 Physical Health

Self or informant rated physical health changed very little over the follow-up period for the whole study population and also for the survivor group. Only one other study in the literature has reported changes in the global health of patients sustaining a hip fracture. Mossey et al (1989) noted relatively little change in the self-rated health of their study population which was comprised of community dwelling American white women aged over 60 at the time of their fracture. In that study 24% of the women rated their health as being excellent prior to their fracture and at 12 months this had declined to 12%. The majority of the women who changed their health status rating moved into the adjacent category labelled good. In the poor category the corresponding percentages were 11 and eight. In the EHFS smaller changes in self-rated health were observed in the SRG of patients. There were just under 40% in the top category at baseline and at 12 months. For individuals who rated their health as being poor or very poor the corresponding figures were 16% and 10%. The survivor cohort showed a similar pattern. The smaller changes in the health status category over the year of follow-up in the Scottish population may in part be attributable to their stoicism which has been noted elsewhere (Guess et al 1993).

Jette et al (1987) using an unselected series of hip fracture patients over the age of 55 years reported 2.4 co-morbid conditions in his study population from the medical records.

In the present study an average figure of 4.1 (SD 2.0) was obtained. This number was derived from a combination of self or informant report and a review of the medical records. In the current study the medical conditions were also categorised in a way to be meaningful to an elderly population, as already discussed in section 3.5.1, and with this definition the average number of medical conditions obtained was 2.9 (SD 1.3). Furstenberg and Mezey (1988) in their selected population of community dwelling residents reported 2.9 (SD 1.6) medical conditions. Mossey et al (1989) using a similar study population reported 3.5 (SD 2.2). It was interesting to note that a review of the medical notes of those patients revealed an average of 6.3 (SD 3.1) medical conditions.

Mossey et al (1989) found the most commonly reported pre-existing medical condition in their community residing residents to be coronary heart disease, with a prevalence of 60%. This was followed by hypertension at 53%, osteoporosis at 51% and arthritis at 46%. In the present study, restricting the focus to the SRG of patients only as this is the most comparable group to the community dwelling residents in the study by Mossey et al, arthritis was the most commonly reported condition with its prevalence being 35%. Coronary heart disease was very close behind with 34%. Visual problems were the next most common at 32% with hypertension coming in at 23%. Differences in the threshold for patient presentation and reporting as well as the intensity of diagnostic practice would explain some of the variability in the observed prevalence of conditions in the two studies.

Greatorex (1988) in his unselected series of English patients over the age of 60 years noted that 77% of his study population had an active medical problem which was defined as a condition which caused disability or required continuous treatment. Using a broadly comparable classification in the present study, 98% of the individuals would have been said to have had an active medical problem. The leading medical condition in the study by Greatorex was dementia at 14%, followed by stroke and arthritis each with 12% and then coronary heart disease at 11%. In his study information was collected from the study participants directly or from an informant where mental clouding was present. In the present study the most commonly reported medical condition for the whole study population was coronary heart disease at 38%, followed by arthritis and visual impairment at 30%.

The literature suggests that the prevalence of a previous hip fracture in both unselected and community-based hip fracture studies was approximately 10% which confirms the result of the current study (Greatorex 1988, Magaziner et al 1990).

#### **4.7.5 Mental Health**

In this section dementia will be addressed first followed by a discussion on depression.



#### **4.7.5.1 Dementia**

In the current study impaired cognitive functioning was indicated by a score of less than seven on the Abbreviated Mental Test based on the recommendation by Hodkinson (1972). (Refer to Appendix 3 for further detail.) Using this operational definition 34% of the study population was considered to have some degree of mental impairment. There was considerable variation in the prevalence levels of mental impairment reported in other hip fracture studies. Billig et al (1986) reported a prevalence of mental impairment of some 40% in their unselected series of patients over the age of 60. Greston (1988) noted a prevalence of 14% in his similar series of patients. Furstenberg and Mezey (1988) noted that 19% of their community residing patients had a persisting mental impairment throughout their period of hospitalisation. Magaziner et al (1990) reported a 10% prevalence of dementia in their community-based sample. Bonar et al (1990) observed a higher level of disorientation amongst their community residing patients at the time of their hospital discharge this being 35%.

The marked variability in the prevalence of dementia reported in the hip fracture literature is mainly attributable to differences in case-finding procedures and the diagnostic criteria used. Research using general populations has indicated that determining the prevalence of mild dementia is particularly problematical (Katzman 1986, Kay 1991). The results from a major European study by Hofman et al (1991) indicated that the prevalence of dementia rose in an exponential manner with increasing age. In the 60 to 64 year olds the prevalence was 1% and this rose to 32% in the 90 to 94 year old age group. In the current study the prevalence of dementia was also noted to increase with age and in the 9th and 10th decades the prevalence was just over 40%.

#### **4.7.5.2 Depression**

As for dementia, the prevalence of depression is very much determined by the methodology used in diagnosis. Various community based studies have however suggested that the prevalence of major depression in the elderly is around 5% and that depressive symptomatology is approximately five times this level in the community (Weissman and Myers 1978, Blazer et al 1987).



In the present study 13 patients were on tricyclic anti-depressant therapy at the time of their fracture. One further patient had been receiving a course of electro-convulsive therapy for severe endogenous depression at the time of her fracture and was excluded from the EHFS on the basis that her depression would interfere with the assessment of her hip fracture. Only eight of the 13 patients who were on tricyclic therapy were classified as being depressed using the short form of the GDS scale. It may be that the other five patients were responding to their therapy and this was why they did not score above five on the GDS scale. Interestingly an additional 44 patients were assessed as being depressed using the GDS scale at the time of their fracture meaning that one third of the study population were classified as being depressed. This may indicate that there is a high proportion of undetected depression in the hip fracture population and this high proportion is in fact consistent with the literature as will be detailed in the next paragraph. However it should be borne in mind that because the patients are being interviewed shortly after their hip fracture it may be that their GDS score is simply reflecting their understandably low mood at that particular point of time of their recovery even though it was emphasised that the patients should base their answers on their mood prior to their fracture. An alternative explanation is that the GDS scale is not a valid measure of depression in a hip fracture population. It is also recognised that further research is required to establish the usefulness of the short form of the GDS scale (RCP and BGS 1992).

In the current study 31% of the patients were noted to be depressed using the Geriatric Depression Scale at their baseline interview which corresponds closely to what has been reported in the general elderly population. Billig et al (1986) also noted that approximately 30% of their hip fracture population were depressed following their surgical management. Detailed questioning was undertaken in this study and the final diagnosis was based on consideration of three different measuring instruments. Magaziner et al (1990) also found that around 30% of their community-based hip fracture patients were depressed at the time of their baseline interview using the Center for Epidemiological Studies Depression Scale (CES-D). Mossey et al (1989) however found a higher proportion of individuals were depressed following the definitive management for their hip fracture this being 51% when they used the CES-D. By one year post-fracture the

proportion of people with depression had dropped to 20%. In the current study the proportion of people with depression had risen from 31% to 37% at the end of their year of follow-up in patients for whom this data was available. A similar picture was seen with the survivor cohort. An important point to note with the GDS was that only one of the questions was directly related to physical functioning which is obviously relevant to a hip fracture population.

#### **4.7.6 Mobility**

The literature suggests that the impact of a hip fracture on mobility is much more substantive than the effect of ageing. Marottoli et al (1992) noted that the decline in physical functioning for an elderly community-residing population has shown to be between four to six percent over one year for many parameters. The ability to climb stairs was the mobility variable to show the most change, with there being a 14% decline over a one year period of follow-up.

When reviewing the functional outcomes from different hip fracture studies differences in the selection criteria used for patients and other factors such as the outcome measures employed must be considered. Selection criteria include place of residence, mental status, rehabilitation potential or pre-fracture level of mobility. A study which enrolled only community-residing residents prior to their fracture for example would be expected to have very different results from another study which used an unselected series of patients as the community-based study population would have a better functional baseline. Much of the published work on functional outcome has restricted itself to community-residing individuals as this is the group which is most amenable to rehabilitation. In this section the changes in mobility due to a hip fracture will be discussed firstly for unselected series of individuals followed by studies limiting themselves to community-residing individuals prior to their fracture. It should be noted that only limited comparisons could be made due to differences in the variables selected in the various studies compounded by a restricted presentation of data in many of the papers.

Most studies show that virtually all of the functional recovery is attained by six months post-fracture and little further improvement occurs thereafter and the current study confirms this pattern (Katz et al 1964, Ceder et al 1980, Jette et al 1987, Magaziner et al 1990, Marottoli et al 1992).

#### **4.7.6.1 Unselected Series of Patients**

Dependence on walking aids has been reported in the literature to change markedly following a hip fracture, as would be expected. Greaux (1988) reported that 57% of his study subjects used no aid immediately prior to their fracture but that this had declined to 13% six months later. Keene et al (1993) noted a similar proportion of individuals not using a walking prior to their fracture and reported that by one year 40% did not use an aid. In the current study 56% of people did not use an aid inside prior to their fracture but this had declined to 32% at the end of the year follow-up. Overall, Sernbo and Johnell (1993) noted that 50% of their patients used more dependent forms of walking aid a year following their fracture. Ceder (1980) noted that if patients came from their own homes their dependence on aids pre-fracture was less and that their mobility recovery, as gauged by their aid usage, was better at three and 12 months. This is in accord with the findings of the present study.

A deterioration in walking distance following a hip fracture has not surprisingly been reported in the literature. Keene et al (1993) noted that 28% of their study population was housebound prior to their fracture rising to 46% a year later. A comparable baseline figure of 27% was obtained in the current study but it declined to 24% by the end of the follow-up. When survivors only were considered there was an increase in the proportion who became housebound but this was only by 4%. The reason for the difference in the secular changes in the two studies is not clear.

Turning now to consider the ability to get out of a chair 17% of the patients in the study by Greaux (1988) who survived the six month follow-up could no longer get out of a chair without assistance whilst they had been able to do so prior to their fracture. In the current study this rise was 5% for a high chair and 24% for a low chair for the survivor

cohort at six months post-fracture. Greatedex (1988) did not specify the height of the chair in his study. Greatedex (1988) also observed that there was a 34% decrease in the ability of his patients to climb stairs at six months compared to their baseline ability. In the current study a strictly comparable variable was not used but it was noted that the proportion of patients in the survivor cohort who could not manage stairs at all rose from 15% at baseline to 24% at six months, with a further 3% increase at one year. These figures clearly indicate the decline in mobility following a hip fracture.

#### **4.7.6.2 Selected Series of Patients**

The majority of studies in the literature that have used a selected series of patients have restricted themselves to either community-residing individuals or individuals suitable for a rehabilitation programme, which mainly comprises community-residing people. These studies therefore were investigating the more able patients.

As for the unselected series of patients, the first mobility parameter to be reviewed will be the dependency on walking aids. In the study by Mossey et al (1989) only 19% of the study population required assistance with walking prior to their fracture. However at 12 months post-fracture only 21% of individuals could walk outside without an aid. This obviously represents a considerable deterioration in walking ability. This change is even more dramatic when the fact that Mossey et al (1989) used a very high functioning group of individuals for their study is taken into account. These people were community-dwelling, ambulatory, white females without 'post-surgical cognitive impairment'. Marottoli et al (1992) also reported a considerable decline in walking ability over a six month follow-up period in their cohort of community-residing individuals. These researchers found that the proportion of people who could walk unaided across a room changed from 75% prior to the fracture to only 15% who could manage this six months later. Of the 536 community-residing subjects studied by Magaziner et al (1990) just under 40% had regained their pre-fracture walking ability two months after hospital discharge in terms of the walking assistance required. This reached 60% at six months post-fracture and showed no further improvement overall in the following six months. During the latter six months 11% of individuals did in fact regain their pre-fracture walking

ability but 10% deteriorated. Jette et al (1987) similarly reported that one year after the fracture 62% of their rehabilitation patients had regained their pre-fracture level of walking aid use inside and 53% outside. Katz et al (1964) however in their series of rehabilitation patients found that only 28% of his patients had returned to their pre-fracture walking level in terms of assistance required by one year. It must be borne in mind that this is a relatively early study and that many advances in operative techniques have been made in the interim which facilitate the rehabilitation process.

The SRG in the current study corresponds to a selected series of high functioning individuals. When compared to the other selected series of patients the current study SRG did in fact make a better recovery with respect to their mobility inside with 36% being able to walk unaided a year after their fracture. Nonetheless this still represents a considerable decline in mobility as 65% could walk unaided prior to their fracture. A larger proportional decrease was however seen for independence outside with 45% of patients not using any walking aid prior to their fracture compared to only 11% at one year. The survivor cohort started from a baseline figure of 49%.

It was interesting to note that there was no real change in the proportion of individuals who were housebound over the year of follow-up in the current study with the proportion remaining around 15%. However the proportion of survivors who could walk half a mile or more halved over the study period which added further evidence to the overall picture of a marked decline in mobility following a hip fracture even in individuals with a high pre-fracture level of functioning. This decline was even more dramatic in the study by Marottoli et al (1992). At baseline 41% of patients could walk half a mile unaided whereas at six months post-fracture only 9% could manage this. When the sub-group of very high performing individuals at baseline in this study were looked at the decline was even more marked with the change being from 75% to 9%. In the current study it was interesting to note that overall only 12% of the SRG reported at one year post-fracture that their walking ability had returned to their pre-fracture level in terms of both aid usage and walking distance.



As for the unselected series of individuals, the ability to get out of a low chair independently was more significantly affected than the ability to get out of a high chair. In the current study 10% of the survivor cohort of the SRG of patients required help to get out of a low chair prior to their fracture whilst by 12 months post-fracture this had risen to 35%. The corresponding figures for a high chair were 3% and 6%. A large decline was also seen in the proportion of patients who could climb stairs independently following their hip fracture. Marottoli et al (1992) reported that 63% of their study subjects were able to do this prior to their fracture and this dropped to 8% by six months post-fracture. When the very high functioning individuals at baseline in the study by Marottoli et al (1992) were looked at only the decline was more pronounced this being from 97% to 12% respectively. In the current study the stair climbing ability was less severely affected. 77% of the SRG could climb stairs with no difficulty prior to their fracture whereas at 6 and 12 months the corresponding percentages were 47% and 55%.

#### **4.7.7 Hip Function**

Assessment scales for hip function have been used in orthopaedic studies looking at the outcome of selected series of patients undergoing a specific surgical procedure. The results of these studies are not directly comparable with the current study because of the selected nature of their study population and because their follow-up results are often reported for five or more years only (Salvati and Wilson 1973, Beckenbaugh and Ilstrup 1978, Pun et al 1988, Kavanagh et al 1989). Furthermore different type of scales have been used which makes comparison more difficult. Even though the same clinical parameters of pain, walking ability, function, and mobility are included in the various scales, different weightings are given to the various components of the scales (Merle d'Aubigne and Postel 1954, Shepherd 1954, Larson 1963, Harris 1969, Wilson et al 1972). Interestingly though, there is comparability of the global scores obtained from each of the scales (Galante 1985). A further problem with all but the most recent of scales is that they have not been subjected to psychometric testing (Johanson et al 1992).

The evaluation of hip function in the majority of studies that have been published is primarily made from assessing mobility in terms of the distances able to be walked,



coupled with the type of walking aid used. The results of these studies have been reviewed in the mobility sub-section.

An interesting observation in the current study was that although a significant degree of shortening was observed in 12% of the study population and 16% experienced moderate or more severe hip pain at 12 months post-fracture, the deterioration in mobility was greater than one would have expected from these factors coupled with the effects of ageing. Psychological factors may have an important role for the disproportionate decline in mobility. At baseline 32% of the survivor cohort reported, or had reported for them, a fear of falling but this rose over the year of follow-up to 62%. Thus fear of falling may have limited an elderly person's walking ability. A recent study by Tinetti et al (1994) found that 43% of their elderly community-residing subjects acknowledged a fear of falling, which was comparable to the 42% found in the SRG of the present study, and that 19% avoided activities because of this fear. It was also interesting to note in the EHFS that the ability to sit comfortably in any chair improved over the final six months of follow-up from 70% to 79% in the survivor cohort whilst all the other components of the Harris Scale deteriorated.

#### **4.7.8 Hip Pain**

Pain is a very important determinant of hip functioning. However it has not been widely reported in the epidemiological literature as an outcome variable with only three studies reporting it to date. Greatorex (1988) found that 64% of his unselected series of patients had hip pain at six months post-fracture. Keene et al (1993) reported a significantly higher prevalence of pain in the patients who had suffered an intracapsular fracture compared to an extracapsular fracture. Pain in their study was reported in terms of an average score using a scale with Guttman scaling. Mossey et al (1989) in their selected series of patients reported that 49% of their patients had no hip pain at 12 months post-fracture, 45% had intermittent pain whilst 9% had persistent pain. The results of the current study are comparable with that of Mossey et al (1989) with 55% of the patients having no pain, 28% intermittent or mild pain, 8% moderate pain whilst 9% had more severe pain. These results indicate that pain is an important outcome measure following a hip fracture.

#### **4.7.9 Self-care**

Most of the results for self-care are subsumed in the literature by being reported in terms of the primary activities of daily living (PADL) which encompass mobility parameters. The only study in the literature to report self-care activities directly is the one by Marottoli et al (1992). These researchers reported that 86% of their community residing patients could dress independently prior to their fracture, whilst at six weeks 42% of individuals could manage this and at six months 49% were able to. In the present study a better recovery in dressing was observed in the SRG of patients. 86% were similarly able to dress themselves without any difficulty prior to their fracture but at one month this proportion was 80%, at six months 82% and at one year post-fracture this was 80%. The self-care PADL most affected by the hip fracture in the current study was the ability to bath, presumably because of the importance of mobility in being able to get in and out of a bath. At baseline 42% of the patient group had no difficulty with bathing. This had declined to 10% at one month, rose to 19% at six months and then there was no further improvement over the ensuing six month period. These results confirm the finding by Katz et al (1964) that the self-care variables are less affected than the mobility variables following a hip fracture. Additionally the data from the present study show that the self-care variables with a high reliance on mobility are more profoundly impaired than self-care variables that do not. For example, getting in and out of a bath was more affected than the ability of the patient to brush his/her hair.

#### **4.7.10 Instrumental Activities of Daily Living**

The instrumental activities of daily living (IADL) are more dependent on walking ability than the primary activities of daily living (PADL) as they are assessing a higher level of functioning. Not surprisingly greater impairment in the ability to perform the IADLs has been observed in hip fracture populations than with the PADL at baseline and the impact of the hip fracture on them has been greater.

Mossey et al (1989) reported that 89% of their white community patients over the age of 60 who were fully ambulatory prior to their fracture were completely independent in their instrumental activities of daily living (IADL) prior to their fracture using the Multi-level

Assessment Instrument. At 12 months post-fracture this figure had dropped down to 41%. Using the SRG group in the current study, for comparability with the study population used by Mossey et al, the impact on the IADLs can similarly be seen. At baseline 42% of the patients had a Clackmannan score of three or less, indicating that they were in the least dependent category, but by 12 months post-fracture this proportion had declined to 28%.

In the current study it was possible to look at the impact of the hip fracture on specific IADL. Light housework was the least impaired IADL pre-fracture with 60% of the SRG of patients being able to manage this without difficulty and the ability to do heavy shopping was the most impaired with only 15% of patients being able to do this without any difficulty prior to their fracture. One year after the fracture 50% of the patient group reported no difficulty doing light housework whilst only 3% were able to do the heavy shopping without any difficulty. The decline in ability to perform the IADL has implications for the community services which will be discussed in the next section.

#### **4.7.11 Dependency**

One measure of dependency is the ability to perform the primary activities of daily living which cover basic mobility and self-care activities which have previously been discussed. The literature indicates that there is a considerable decline in functioning in PADLs following a hip fracture. Grotorex (1988) in his unselected series of patients over the age of 60 revealed that 52% of his patients deteriorated in their PADLs over the six months of follow-up. It should be noted that only 35% of this study population were fully independent in their PADL prior to their fracture indicating that the majority were starting from an impaired baseline. Jette et al (1987) showed that only 33% of his unselected study population over the age of 55 regained their pre-fracture level of PADLs in all domains over the one year follow-up period. Using a community residing population Magaziner et al (1990) observed that 70% of their hip fracture patients were independent in their PADLs prior to their fracture but that after a year only 40% of the population were. Similar results were found by Katz et al (1964). These researchers found that 43% of their patients returned to their pre-fracture level of PADL functioning at six months and

that there was only a further 5% improvement over the following six months. In the current study the changes in dependency followed the same general trend as was observed by Katz et al (1964).

The variable 'how the patient managed on a daily basis' was also taken as a general indicator of dependency in the present study. Thirty-two percent of the survivor cohort were reported not to have any difficulty managing prior to their fracture but this dropped to 16% one year later. The majority of individuals who deteriorated moved down to the 'some difficulty' category. The proportion who 'did not manage' remained fairly static at approximately 10%. Reviewing the number of people in the whole study population the number of people who were in the 'did not manage' category the number actually dropped over the one year follow-up period from 36 to 19 due to the increase in dependency of surviving individuals being offset by the death of the frailer individuals.

An increased reliance on community services after a hip fracture has also been documented elsewhere indicating increased dependency. Ceder et al (1979) reported a 32% increase in the reliance on home help services by community residing individuals one year after their hip fracture. An increase in the average number of community services was also observed in the current study for the survivor cohort. The increased dependency of the surviving patients in the present study was evidenced by the fact that the proportion of patients who required home helps and were still resident in their own homes rose from 38% to 47%.

#### **4.7.12 Social**

Social ties and the support and the assistance that they can provide may be critical factors in enabling an elderly hip fracture patient to maintain their independence and continue living in a community setting as well as providing psychological support. The general literature suggests that social relationships and health are connected although the direction of the association is controversial (Cassel 1976, Cobb 1976, Kaplan et al 1977, Reed et al 1983, Cohen et al 1985, Seeman et al 1987, Hanson and Ostergren 1987). The study by Magaziner et al (1990) reported independent predictive effects of social relationships on functional outcome following a hip fracture. A larger social network size was predictive

of better IADL whilst more contact with the network was additionally predictive of walking ability and physical dependency. It should be noted that the predictor social variables in this study were recorded in the first few months of the rehabilitation period which means their results are not necessarily generalisable. Mossey et al (1990) on the other hand found no multivariate relationship with 'contact with a special person' and the 'number of close children, friends or relatives'. The current study found no association with network size and frequency of contact with the social network. It did however highlight the restricted social contact of the elderly hip fracture population.

#### **4.8 SUMMARY**

An unselected series of 270 hip fracture patients over the age of 60 years with a presumed osteoporotic fracture were followed up to one year post-fracture. Fifty nine patients were excluded from the study on the basis of probably not having an osteoporotic fracture, being moribund or dying within a week of their fracture. Additionally one patient refused to participate in the study. Case ascertainment following cross-checking with data supplied from ISD for patients treated in Lothian was found to be over 99% complete. The age- and sex-specific incidence rates for hip fracture in the EHFS were comparable to that reported in the literature and clearly indicated the rising incidence with age and the doubling of risk for women. Thirty nine percent of the study population required an informant to provide information on their behalf in order to obtain data of reasonable quality largely because of the presence of dementia. A nested validation study was incorporated into the EHFS to ascertain whether the data provided by an informant was comparable to that provided by the patient had they been able to do so. Reporting bias was only found for functional status and this has been previously documented in the literature. The results of this small study indicated it was reasonable to use data from an informant where this was required. The validation study also indicated that the choice of informant was not crucial.

Information about the pre-fracture status of the patient was collected within one week of his/her hospital admission. Overall, the study population was found to be elderly, frail and dependent prior to their fracture. The key variables within each of the domains were



found to correlate significantly with one another. The only exception to this were the social variables which yielded few significant correlations. The majority of the baseline variables however only had weak associations with other baseline variables as indicated by the magnitude of their Spearman's correlation coefficients. This meant that confounding would not be a major problem for the EHFS. Moderate to strong associations were however noted amongst the mobility variables and strong associations were obtained for the associations of the dependency variables with each other and with the self-care variables.

Patients were followed up at one, six and 12 months post-fracture. The data collection was over 99% complete. The cumulative mortality was 29%. Sustaining a hip fracture resulted in considerable morbidity. The domains for which this was most evident were mobility and dependency. 62% of the survivor cohort were able to walk without an aid inside prior to their fracture compared to 32% one year later. Dependency as gauged by the Barthel Index rose from 10% to 25% over the year. The impact at the community level was less marked due to the frailer individuals dying during the period of follow-up. For example, only 10 additional people were classified as being dependent by the Barthel Index over the one year period of follow-up in the whole study cohort. A general pattern of recovery emerged. At one month post-fracture there was marked impairment. Partial improvement occurred over the next five months after which the recovery plateaued. At one year post-fracture significant problems directly related to the hip fracture were still present. Seventeen percent of patients complained of a severe limp and 12% had a significant degree of femoral shortening. Nine percent of the patients complained of severe pain which seriously limited their activities and/or required the frequent use of a moderate strength analgesic. The decline in functioning overall of the study population was greater than what would have been expected from an orthopaedic viewpoint coupled with the effects of ageing. This may be due to the fear of another fall restricting the patients' activities.



## **CHAPTER 5**

### **PREDICTION OF ONE MONTH OUTCOME**

#### **5.1 INTRODUCTION**

The purpose of this chapter is to present the baseline predictors for each of the four selected one month outcome variables namely mortality, accommodation, depression and dependency. Refer to section 3.5.2 for further detail on the selection of the outcome variables. Specific inclusion and exclusion criteria will be made explicit for each outcome variable. The approach to the statistical analyses and the stratification of the baseline variables for the multivariate analysis have been outlined in section 3.7.2. The univariate results will precede the multivariate findings for each outcome variable which in turn will be followed by a discussion relating the results of the current study to the studies reported in the literature. Examples of predictive use will be given for the prognostic indices derived for the outcome variables from the multivariate analyses. The clinical application for the indices derived for accommodation and dependency will be discussed because of their potential role in facilitating the selection of patients for the Early Supported Discharge Schemes outlined in section 1.3.3.2.4.

The univariate analysis results are tabulated in Appendix 10 due to their extensive nature.

#### **5.2 ONE MONTH MORTALITY**

At one month post-fracture 19 deaths had occurred in the study population which represented 7% of the patients. No exclusions were made for this analysis.

##### **5.2.1 Univariate Analysis**

The important univariate results are summarised in Appendix 10 and clearly indicate the association of advanced age, poorer mobility and increased dependency with mortality. It was interesting to note that the patient's sex, fracture type, co-morbidity and mental state, as gauged by the AMT score, were not significantly associated with survival at one month post-fracture.

### **5.2.2 Multivariate analysis**

A logistic regression analysis was performed using the stratified stepwise approach outlined in section 3.7.2.3.

#### **5.2.2.1 Selection of First Line Variables**

As outlined in section 3.7.2.3 the stratification of the baseline variables for use in the stepwise regression models was based on a review of the literature combined with clinical judgement. The most important 12 variables identified were then used as the first line variables. The remaining variables were then classed as second or third line variables based on their perceived importance and added sequentially to the stepwise regression models.

Age has been included as a predictive factor in all studies looking at early hip fracture deaths and is intuitively an important predictor of mortality (Riska 1970, Jensen and Tondevold 1979, Dahl 1980, Davidson and Bodey 1986, Dolk 1989, Myers et al 1991). Sex as a risk factor for mortality has also been considered (Jensen and Tondevold 1979, Dolk 1989, Foubister and Hughes 1989, Myers et al 1991). Both of these demographic factors were included as potential first line predictors in the current analysis. Pre-fracture place of residence has been looked at in relation to early death as has mental state (Engh et al 1968, Davidson and Bodey 1986, Broos et al 1989, Dolk 1989, Foubister and Hughes 1989, Myers et al 1991). Baseline accommodation, total AMT score and study status were consequently incorporated as possible first line predictor variables. General health and the number of coexistent medical conditions of the elderly hip fracture patient has also been found to be predictive of in-hospital death (Dahl 1980, Broos et al 1989, Dolk 1989, Kernek et al 1990, Myers et al 1991). The general health of the patient, their total number of medical conditions, their number of categorised medical conditions, as well as their number of medications were included as potential first line predictors to cover co-morbidity. Poor pre-fracture mobility and dependency has also been noted to be associated with an increased risk of death (Broos et al 1989, Foubister and Hughes 1989). The total Barthel score and 'how the patient managed on a daily basis' were

included as possible first line predictors to cover these domains. A few studies have investigated the relationship between fracture type and early mortality and have found no association (Dahl 1980, Beringer et al 1984, Dolk 1989, Magaziner et al 1989, Broos et al 1991). Despite this, fracture type was included as a potential predictor because in other studies a higher mortality has been observed in patients with an extracapsular fracture at twelve months post-fracture. Refer to section 6.2.2.1.

#### **5.2.2.2 First Line Variables in Regression Model**

Only two first line variables were entered into the logistic regression model and these were 'how the patient managed on a daily basis' and age. Increased dependency and advanced age were predictive of increased mortality. The regression model is given in Table 5.1. The probabilities of the other baseline variables which did not attain the required 10% significance level to be entered into the model are given in Table 5.1.

When a backward regression procedure was performed to test the robustness of the model the number of medical conditions and the number of medications entered the model as well as age and 'how the patient managed on a daily basis'. However it was noted that the coefficient for the number of medical conditions had the wrong sign and therefore its association with one month mortality was probably spurious. The direction of the multivariate association was counterintuitive with patients on more medications being more likely to survive. The term was consequently dropped from the model. In effect, a one tailed test of significance was being performed. However all the significance levels presented in the univariate tables are those appropriate to a two tailed test. Reviewing Appendix 10 it can be seen that the number of medical conditions did not reach significance at a univariate level of analysis but the right direction for the association was obtained. The backward regression was re-run without the number of medical conditions and the same model was obtained as with the forward procedure.

**Table 5.1** One month mortality logistic regression analysis**A. FIRST LINE PREDICTOR VARIABLES****1. Forward stepwise regression****a) Significant variables**

Variable	Coefficient	Standard error	P
Intercept	9.48	3.00	-
Age	-0.073	0.035	0.039
Managed on a daily basis	-0.63	0.24	0.0079

**b) Non-significant variables**

Variable	P
Sex	0.69
Accommodation	0.43
Study status	0.95
General health	0.28
Number of medical conditions	0.43
Total number of categorised medical conditions	0.50
Number of medications	0.14
Total AMT score	0.65
Total Barthel score	0.57
Fracture type	0.82

**2. Backward stepwise regression**

Same regression model generated as from forward procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	9.08	2.93	-
Age	-0.066	0.034	0.054
Managed on a daily basis	-0.28	0.29	0.33
Inside walking aid	-0.23	0.10	0.016

**5.2.2.3 Final Regression Model**

Adding in the second line variables resulted in the inside walking aid being included into the model at the 5% level of significance. Patients who were more dependent in their walking were less likely to survive to one month post-fracture. It was interesting to note that 'how the patient managed on a daily basis' was confounded by the inside

walking aid as reflected by the increase in its probability from 0.0079 to 0.33 when the inside walking aid variable was added into the model. No third line variables were added into the model at the 1% level of significance.

Logistic regression analysis permits the magnitude of the association between a predictor variable and a binary outcome, in this case mortality, to be estimated after adjusting for a number of confounding factors simultaneously. The risk of a particular outcome is expressed as a function of independent predictor variables. If P is the probability of surviving then  $P/(1-P)$  represent the odds of surviving. If the natural logarithm of  $P/(1-P)$  is then taken the relationship between the dependent and independent variables may be expressed as a simple linear equation of the form :

$$\ln(P/(1-P)) = a + b_1x_1 + b_2x_2 + \dots + b_nx_n$$

The coefficient of each of the independent variables represents the magnitude of the change in the log odds produced by one unit of change in the independent variable with all the other variables held constant. For example, in the current analysis the fitted coefficient for age was -0.066 which means that the log odds of surviving would decrease by 0.066 for each year increase in age. The odds ratio for an independent variable derived from a logistic regression model is an estimate of the relative odds of that variable that is adjusted for confounding by other variables present in the model. It is calculated by taking the antilogarithm of its coefficient (Hennekens and Buring 1987). A value of below one for the odds ratio indicates that the independent variable is associated with a reduced chance of developing the outcome of interest and a value greater than one means that there is a higher risk (Fletcher et al 1988).

The logistic regression model generated for one month mortality was :

$$y = 9.08 - (0.066 \times \text{age}) - (0.28 \times \text{managed on a daily basis}) - (0.23 \times \text{inside walking aid})$$

The numerical values to be used in this formula for each of the categorical variables are shown in Appendix 11. From this model it can be calculated that for each decade increase in age the odds of surviving was reduced to 51%. The independent effect of

a change in dependency as gauged by the four point scale for the variable 'how the patient managed on a daily basis' was more marked with one increment in dependency corresponding to an odds of 0.76 of surviving. A one point increase on the nine point scale for walking dependency was associated with an odds of 0.79 of surviving.

### 5.2.3 Prediction in Practice

The probability of a patient being dead at one month post-fracture may be estimated by inserting his/her baseline characteristics into the logistic regression model  $y = 9.08 - (0.066 \times \text{age}) - (0.28 \times \text{managed on a daily basis}) - (0.23 \times \text{inside walking aid})$  to generate a value of y. The probability of death is then determined using the formula  $p = 1 / (1 + e^y)$ .

To illustrate this, if a 95 year old woman fractured her hip and prior to this did not manage on a daily basis and needed two people to help her walk with a zimmer then her y value is  $y = 9.08 - (0.066 \times 95) - (0.28 \times 3) - (0.23 \times 7) = 0.36$  and her probability of dying is  $p = 1 / (1 + e^{0.36}) = 0.41$ . On the other hand the probability of a 65 year old lady who had no difficulty managing on a daily basis and walked unaided prior to her fracture dying during the first month following her fracture can be calculated to be 0.0082 using the same approach.

In Table 5.2 the predicted probabilities of death derived from the regression model are tabulated against the actual survival status of the patients. It can be seen that none of the patients were predicted to die

**Table 5.2** Predicted versus observed mortality

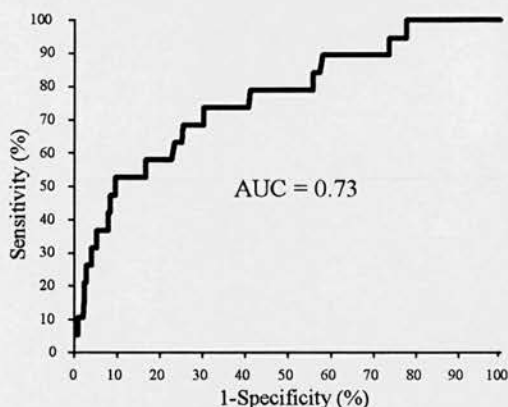
Predicted probability	Observed frequency			Observed probability
	Dead	Alive	Total	
0.00-0.09	9	209	218	0.04
0.10-0.19	3	26	29	0.10
0.20-0.29	4	10	14	0.29
0.30-0.39	2	5	7	0.29
0.40-0.49	1	1	2	0.50

with a probability of above 0.50 and hence the use of this index to predict mortality is unlikely to be of any great value. This has arisen because only 19 individuals had died by one month post-fracture. The observed and predicted probabilities in the table



were fairly similar for mortality at one month giving some support for the reasonableness of the logistic model.

Another way of presenting the utility of the regression model to predict mortality is to construct a receiver operator characteristic (ROC) curve. This is done by plotting the true positive rate (sensitivity) for mortality obtained with the regression model against



**Figure 5.1** One month mortality ROC curve

the false positive rate (1-specificity) for all possible values of the regression model.

See Figure 5.1. A model which contributes no useful information will yield a diagonal line. In order for a model to be helpful a high true positive rate should be coupled with a low false positive rate so the area under the curve (AUC) is large.

The AUC gives the overall accuracy of the regression model but its interpretation is

subjective. In Figure 5.1 the AUC is 0.73 and it can be seen for example that a cut-off point which gives a true positive rate of 80% corresponds to a false positive rate of 44%. In other words, with this cut-off there is an 80% chance of correctly predicting death and a 56% chance of correctly predicting survival. The exact value chosen from the range of values generated from the regression model to use as the cut-off point to determine the models sensitivity and specificity (true negative rate) is arbitrary. It can be clearly seen in Figure 5.1 that the true positive rate rises with the false positive rate indicating there is a trade-off between sensitivity and specificity.

#### 5.2.4 Discussion

Most of the literature on hip fracture mortality has looked at survival at six months or one year post-fracture. The limited number of studies which have addressed the short term survival of hip fracture patients have tended to look at their in-hospital survival. This has the inherent difficulty of not being a fixed interval of time. In-hospital mortality for unselected series of patients has been noted to range from 8.6% to 28%

(Jensen and Tondevold 1979, Davidson and Bodey 1986). The average length of acute hospital stay has been reported in the literature to vary from 14 to 51 days (Davidson and Bodey 1986, Pettiti and Sidney 1988). The length of hospital stay has in fact been steadily reducing over the last three decades. In 1966 the mean hospital stay for survivors was 47 days in Sweden. By 1972 it was 30 days and in 1977 it had dropped further to 26 days (Ceder et al 1980). Over the period 1979 to 1990 the length of stay in Australia was noted to have declined from 32 days to 21 days (Lord 1993). In America an average length of stay of only 9 days has recently been reported. This short length of stay was attributed in part to the introduction of the diagnostic related groups which encourage early acute hospital discharge (Ensberg et al 1993). In Lothian the mean length of hospital stay for hip fracture patients has declined from 36 days in 1981 to 18 days in 1991 (Muir 1994).

In the studies looking at in-hospital mortality much emphasis has been placed on the medical complications that have arisen. The in-hospital complications are not of relevance to the current analysis as the baseline factors are limited to pre-fracture variables.

Direct comparisons between the early mortality studies are also hampered by the different study populations that have been investigated. Studies which have limited themselves to patients who were resident in the community before their fracture, for example, would expect to have a lower mortality rate than studies in which institutionalised patients had been included. Furthermore, most of the studies which have been performed have been descriptive or have only employed univariate statistical methods. Multivariate techniques are required to ascertain independent risk factors.

In the current study 7% of the patients had died by one month post-fracture. If the 13 patients who were obviously moribund at the time of their fracture were included into the mortality calculation this would yield a one month mortality figure of 17%. This is comparable to the 18% that has been reported in the literature for similar series of

unselected patients with comparable average ages (Riska 1970, Dahl 1980, Foubister and Hughes 1989). A higher mortality would be expected in the earlier studies due to advances in surgical and anaesthetic techniques that have occurred over the last three decades.

The present study confirmed the importance of age in predicting an early death following a hip fracture (Riska 1970, Beals 1972, Jensen JS and Tondevold 1979, Dahl 1980, Davidson and Bodey 1986, Pettiti and Sidney 1988, Broos et al 1989). 2.9% of the current study population under the age of 80 years died during the month post-fracture compared to 9.5% over this age which was significant in univariate analysis. The importance of age as an independent risk factor for early death was evidenced by the fact that it was the second term to enter the stepwise regression model. Jensen and Tondevold (1979) and Dolk (1989) also reported multivariate significance for age.

Several studies have reported a significant univariate association of male sex with early death which contrasts with the present study (Jensen and Tondevold 1979, Dahl 1980, Broos et al 1989). This association was preserved multivariately in the study by Jensen and Tondevold (1979). Davidson and Bodey (1986) noted a higher death rate in men but it did not attain statistical significance. In the current study men were significantly younger than women by four years but their one month mortality was comparable to that of the women. This was not surprising given the higher age-specific mortality in men (Registrar General for Scotland 1994). It should be noted however that only three men had died by this stage of follow-up.

Pre-fracture accommodation was found to be significantly related to mortality at three months post-fracture at a univariate level in the studies by Broos et al (1989) and by Foubister and Hughes (1989). It was also a finding in the present study for one month mortality but it did not attain significance multivariately. Dolk (1989) using multiple discriminant analysis reported a higher in-hospital mortality amongst institutionalised patients. As the type of accommodation is an indicator of general

frailty it is not surprising that this significant relationship was observed, although community residing patients did not fare significantly better than institutionalised patients in the present study.

The only study to report a significant univariate relationship with fracture type and early mortality was the one performed by Jensen and Tondevold (1979) using an unselected series of patients over the age of 50 years. At a multivariate level fracture type was noted to be confounded by age and did not attain independent significance. In the present study intracapsular fractures were not found to be related to a higher mortality even at the univariate level.

In the literature, general health, presence of dementia, poor functional status, impaired pre-fracture mobility have all been reported to be associated with early mortality at a univariate level (Beringer et al 1984, Davis et al 1988, Broos et al 1989, Foubister and Hughes 1989, Magaziner et al 1989). The present study confirms these findings with the exception of dementia. Magaziner et al (1989) also found concomitant disease and delirium to be predictive of death at a multivariate level within three months of a hip fracture. In the current study general health variables were noted to be confounded by the variable 'how the patient managed on a daily basis'. Although all of the mobility variables in the present study, apart from the ability to get out of a low chair, were highly significantly related to early mortality only the type of walking aid used inside attained significance multivariately due to their inter-relationships. Dependency, as gauged by 'how the patient managed on a daily basis', also reached significance at a multivariate level in the current study. This has not previously been documented in the literature.

In summary, despite the small number of deaths at one month post-fracture in the current study significant independent predictors were identified. Age was not surprisingly the most important of the three baseline variables that attained multivariate significance. Dependency as gauged by 'how the patient managed on a daily basis' and the type of inside walking aid required were also predictive and are



new findings in the literature. The main unexpected findings in the current study were that general health and mental state were not found to be independent predictors of early mortality, with the latter not even achieving univariate significance. This may be related to the relatively few deaths which had occurred at one month post-fracture thereby reducing the power of the study to detect significant relationships. Only one study, which assessed mortality at three months post-fracture, has reported significant multivariate associations for general health and cognition with mortality. The regression model in the current study performed reasonably well as assessed by the 0.73 area under the ROC curve. However, in clinical practice the regression model would not be of great use because no patient had a probability of dying of greater than 0.50. This arose because only 19 patients had died by one month post fracture. Further research into the predictors of early mortality is required especially in light of the recent recommendation by the Scottish Office Clinical Research and Audit Group that 30 day mortality should be an outcome measure for clinical audit of hip fracture patients as outlined in chapter 1 (CRAG 1994).

### **5.3 ONE MONTH ACCOMMODATION FOR SELF-REPORTING GROUP**

It was decided to restrict this analysis to patients who were resident in the community prior to their fracture. Community residence included those individuals who were in sheltered housing or residential care in addition to people in private residences but did not include patients in nursing homes or long stay care hospitals. All patients were used for the analysis regardless of whether or not they actually survived to one month post-fracture. The rationale behind this was so that return to the community could be predicted on all patients when they presented to hospital. No exclusions were made on medical grounds for this reason also.

At one month post-fracture 84 (51%) patients had returned to the community. The 19 (7%) of patients who died during this time interval were considered to have failed to have returned to the community and were put into the institutional category. Patients who sustained a severe medical event interfering with their hip fracture rehabilitation were also included in the analysis.

### **5.3.1 Univariate Analysis**

The variable accommodation at one month was treated as an ordered categorical variable for the univariate analysis. However for the purpose of presentation this variable has been dichotomised into community and institutional residence to be in keeping with the classification used for the multivariate analysis. The more important results for the univariate analysis relating the baseline features of the patient to their place of residence at one month are summarised in Appendix 10.

Age, marital status, fracture type and mental state were all significantly associated with the place of residence at one month post-fracture. Interestingly, pre-fracture accommodation and all of the general health, mobility and dependency variables, with the exception of the Clackmannan scores, did not manage to achieve univariate significance with one month accommodation. Patients who lived with someone prior to their fracture, and for whom their co-resident was their main helper, were significantly more likely to have returned to the community one month after their fracture.

### **5.3.2 Multivariate Analysis**

One month accommodation was dichotomised into community and institutional residence and a logistic regression analysis was undertaken to derive the baseline predictors.

#### **5.3.2.1 Selection of First Line Variables**

Age is intuitively a predictor of short term accommodation and has been included in numerous studies and was consequently included as a first line predictor in the present study (Ceder et al 1980, Dolk 1989, van der Sluijs and Walenkamp 1991, Ensberg et al 1993, Sernbo and Johnell 1993). Sex has also been investigated as a potential predictor of early accommodation (Ceder et al 1980, Thorngren et al 1993). Pre-fracture accommodation and co-residents have similarly been studied in relation to short term accommodation in hip fracture patients (Ceder et al 1980, van der Sluijs and Walenkamp 1991, Ensberg et al 1993, Thorngren et al 1993, Weatherall 1993(b))



and in general medical patients (Wachel et al 1987). General health has also been documented as being predictive of accommodation (Ceder et al 1980, van der Sluijs and Walenkamp 1991, Thorngren et al 1993). To cover this domain the variables self-rated general health and the total number of categorised medical conditions were included as potential predictors in the current study. Mental state has also been documented as having an important bearing on placement in both hip fracture and general medical patients (van der Sluijs and Walenkamp 1991, Ensberg et al 1993). Dependency has been widely investigated as a predictor of subsequent place of domicile. It has been gauged using ADLs, IADLs, walking ability, pre-fracture assistance, and the ability to visit someone (Ceder et al 1980, van der Sluijs and Walenkamp 1991, Ensberg et al 1993, Thorngren et al 1993). In the current study the parameters 'how the patient rated how they managed on a daily basis', total Barthel score, inside walking aid, shopping ability and 'frequency of visiting others' were included to assess the role of mobility and dependency on short term accommodation. Finally, fracture type has been investigated in relation to accommodation in a number of studies, showing a positive association in some, thereby justifying its inclusion as a possible first line predictor in the current study (Ceder et al 1980, van der Sluijs and Walenkamp 1991, Thorngren et al 1993, Weatherall 1993(b)).

#### **5.3.2.2 First Line Variables in the Regression Model**

The most significant variable to be added into the logistic regression model using the forward step-wise procedure was age. Refer to Table 5.3. This was followed by 'how the patient perceived how he/she managed on a daily basis'. The third variable to enter the model was the total AMT score followed by fracture type. In using the logistic regression procedure in SAS it was necessary to add in the categorical variables separately in order to be able to assess their independent effects (SAS Institute Incorporated 1988). Marital status and baseline co-residents were each subdivided into three groups for this purpose and dummy variables generated. Both variables were found to be significant at the 10% level. The next stage was to determine the contribution of each categorical variable when the other categorical variable was in the model. To do this the most significant categorical variable was

added into the model first and then the other variable was added in. Using this approach marital status was rendered non-significant indicating that it was confounded by the variable co-residents.

**Table 5.3** One month accommodation logistic regression analysis for self-reporting group

A. FIRST LINE PREDICTOR VARIABLES			
1. Forward stepwise regression			
a) Significant first line variables			
Variable	Coefficient	Standard error	P
Intercept	3.61	3.18	-
Age	-0.08	0.027	0.0034
Managed on a daily basis	-0.83	0.25	0.0008
Total AMT score	0.47	0.20	0.019
Fracture type	-1.13	0.40	0.0044
Co-residents			0.0023
Dummy co-residents 1	1.48	0.43	0.0006
Dummy co-residents 2	1.94	0.73	0.0083
b) Non-significant variables			
Variable			P
Sex			0.86
Marital status			0.60
Accommodation			0.16
General health			0.21
Total number of categorised medical conditions			0.63
Inside walking aid			0.55
Total Barthel score			0.76
Shopping ability			0.26
Frequency of visiting others			0.43
2. Backward stepwise regression			
Same regression model generated as from forward procedure.			

**Table 5.3 (continued)** One month accommodation logistic regression analysis for self-reporting group

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	3.30	3.29	-
Age	-0.074	0.028	0.0083
Managed on a daily basis	-0.26	0.32	0.42
Total AMT score	0.49	0.21	0.018
Fracture type	-1.27	0.41	0.0021
Co-residents			0.0009
Dummy co-residents 1	1.60	0.45	0.0004
Dummy co-residents 2	2.40	0.77	0.0017
Clackmannan self-care subscale score	-0.27	0.10	0.076

The final model using the first line variables consequently contained five predictor variables namely age, how the patient managed on a daily basis, total AMT score, fracture type and the co-residents at baseline. Older patients who managed less well on a daily basis, had poorer cognitive functioning, an extracapsular fracture, or lived on their own were more likely to be institutionalised at one month post-fracture. If the patient's co-residents were other people in a residential home they were more likely to have returned to the community than if they were relatives or friends. This information is summarised in Table 5.3. The first line variables which did not attain independent significance at the 10% level are given in the same table.

When a backward stepwise procedure was performed using the non-categorical variables the same regression model was obtained as with the forward stepwise procedure indicating that the model was robust.

**5.3.2.3 Final Regression Model**

Adding in the second line variables resulted in two more dependent variables being entered into the regression model at the 5% level of significance. The Clackmannan self-care subscale score was added in first followed by the outside walking aid.

Fourteen observations were however deleted in the analysis due to the presence of missing values. When the program was re-run containing only predictor variables with no missing values the end result was the same. It was noted that the coefficient for the variable denoting the outside walking aid had the wrong sign, that is, it indicated that patients who had greater walking impairment were more likely to have returned to the community at one month post-fracture which is clearly counterintuitive. This association was also in the opposite direction to the univariate findings. Consequently it was removed from the regression model as this represented a spurious association. Reviewing the regression analysis it became apparent that outside walking aid was confounded by the Clackmannan self-care subscale. For accuracy the program was re-run without the outside walking aid variable included in case it had affected the significance of other potential predictor variables. The resulting model was the same. Further review of the regression analysis also revealed that the Clackmannan self-care subscale confounded 'how the patient managed on a daily basis'. The probability of the latter variable rose from 0.0008 to 0.42 when the Clackmannan self-care subscale entered the model.

No third line variables were entered into the model at the 1% level of significance. Variables with missing values did not influence the final regression model obtained. The final model was :  $y = 3.30 - (0.074 \times \text{age}) + (0.49 \times \text{AMT score}) - (0.26 \times \text{managed on a daily basis}) - (0.27 \times \text{Clackmannan self-care}) + (1.60 \times \text{dummy co-residents variable 1}) + (2.40 \times \text{dummy co-residents variable 2})$ . The model is also given in Table 5.3 with the baseline predictor variables being listed in the order in which they entered the regression model.

Pre-fracture co-residents had a very strong bearing on whether the patient had returned to the community one month after their fracture. Patients who lived with residents or those patients who lived with relatives or friends had markedly elevated prospects of returning home compared to patients who lived on their own. Their respective odds were 11.27 and 5.05. It should be noted that 70 (42%) people lived with a spouse, relative or friend whilst only 9 (5%) of the patients lived with other

residents prior to their fracture. The small number of patients in the latter category was reflected by the broad 95% confidence interval obtained for their odds ratio of returning to the community (4.5 to 49.9). The confidence interval for those patients who lived with a spouse, relative or friend was narrower, but nonetheless still quite wide (2.05 to 12.37). Every decade increase in age was associated with an odds ratio of 0.48 of returning home. Patients who had better cognition, as gauged by the AMT score, also had a better chance of returning home. For every increment on the 10 point scale the odds ratio of returning home increased by 1.63. On the other hand patients who sustained an extracapsular fracture had an odds ratio of 0.28 of returning home relative to patients with an intracapsular fracture. A one point increase in dependency as gauged by the four point scale for 'how the patient managed on a daily basis' or the ten point Clackmannan self-care subscore were each associated with a reduced odds ratio of returning to the community these being 0.77 and 0.76 respectively.

### 5.3.3 Prediction in Practice

The logistic regression model derived for one month accommodation for self-reporting patients was :

$$y = 3.30 - (0.074 \times \text{age}) + (0.49 \times \text{AMT score}) - (0.26 \times \text{managed on a daily basis}) - (0.27 \times \text{Clackmannan self-care}) + (1.60 \times \text{dummy co-residents variable 1}) + (2.40 \times \text{dummy co-residents variable 2}) - (1.27 \times \text{fracture type})$$

where the values taken by the independent variables are shown in Appendix 11. For each fully eligible study patient a value for y was calculated and the probability of being in the community at one month was calculated using :

$$p = e^y / (1 + e^y)$$

Two examples will now be given to illustrate the use of the prediction formula at an individual patient level without going into the arithmetic details. If a 73 year old lady presents with an extracapsular hip fracture and she has previously been in good physical and mental health, is independent in her self-care and lives with her husband, then her probability of returning to the community at one month is 0.99. On the other



hand, if a 90 year old lady sustains an extracapsular fracture, lives on her own, has a mild degree of cognitive impairment, has no real trouble managing on a daily basis but was unable to bath unassisted prior to her fracture, then her probability of being in the community at one month is 0.43.

To identify patients who are eligible for the Early Supported Discharge Schemes (ESDS) outlined in chapter 1 there are two possible approaches that could be adopted. Firstly a cut-off value for the value of the index generated from the regression model could be selected. The index values are generated by calculating a value for  $y$  for each patient using the regression model with the constant term excluded. Patients with values above this arbitrary index value would be the ones selected for the ESDS. The index values ranged from -4.79 to 3.70. Selecting a cut-off point of 0.00 for the index would mean that 20 of the 84 patients who were able to return to the community would not be correctly identified and 20 of the patients who were in institutional care would be misclassified as being able to return to the community. The sensitivity and specificity using this cut-off point for the regression model were 76% and 77% respectively. Selecting a lower cut-off point would raise the sensitivity of the model. For example, a cut-off point of -0.50 would mean that 72 patients who returned to the community would have been correctly identified compared to 30 of the institutionalised patients yielding a sensitivity and specificity of 85% and 37% respectively. Given that patients in the ESDS are closely monitored following their hospital discharge, and they can be returned to more supported accommodation if the need arose, it may be preferable to have a high sensitivity for the regression model at the expense of a lower specificity. In this way the number of patients who are potentially able to manage in the community but are not given the benefit of the ESDS is minimised. The second way of selecting patients for the ESDS is to use a predetermined probability of returning to the community. This would then dictate the index value that would be used for the cut-off point, and also determine the sensitivity and specificity of the regression model as discussed earlier. For instance a probability of 0.70 could be chosen and this yields a sensitivity of 58% and specificity of 93%. The higher the probability that is selected the higher will be the

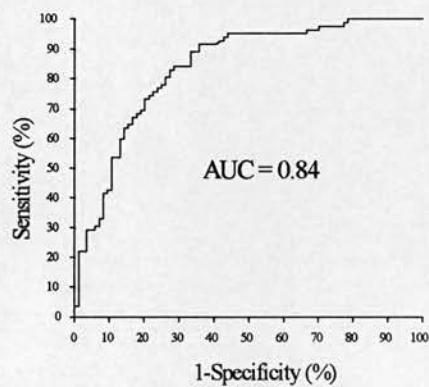
index value with correspondingly lower sensitivities and higher specificities. To illustrate this using, a probability of 0.30 as the cut-off point would yield a sensitivity and specificity of 0.83 and 0.54 respectively. Verification of the utility of the model in predicting outcome needs to be taken on an independent set of patients before a cut-off point for the index is formally assigned. It should be noted that the proportion of patients at the RIE who are now participating in the ESDS has risen since the prediction formula was derived due to a change in management policy which is clear from the decreasing average length of stay outlined in chapter 1. The probability of returning to the community that is derived from the regression model only relates to the rehabilitation of patients that was taking place at the time the EHFS was being conducted. However, despite the change in management, the regression model should still be able to rank the patients from the most able to those least likely to return to the community. After the validation study to detect the usefulness of the predictive models is completed on an independent cohort of hip fracture patients, discussion with clinicians will then be required in order to come to a consensus about the optimal cut-off point to be used. Standard forms would then be completed at the time the patient is admitted to hospital to obtain the relevant information for the regression model so that an index value can be computed. Patients from the community with values above the cut-off point would then be eligible for the ESDS whilst those with lower values are likely to make a slower recovery and would start a rehabilitation programme aimed at rehabilitation through a GORU. Using the prediction formula for return to the community may therefore help guide the selection of the most appropriate initial rehabilitation programme for each patient in a more objective way than is presently available using clinical judgement alone. This could be done at an early stage in the hospitalisation experience for each patient. A reappraisal of the patient's rehabilitation status may of course be required in the light of subsequent events during his/her hospital stay.

Table 5.4 summarises the estimated probability of the patient being in the community at one month compared to their actual residential status. The observed and predicted probabilities were fairly similar for placement at one month providing some support

for the logistic model. For example, an expected probability of 0.30 to 0.39 corresponded to an observed probability of 0.38.

The ROC curve given in Figure 5.2 shows the desirable property of a curve that is well removed from a

45 degree line which would be obtained if the regression model had been



**Figure 5.2** One month accommodation ROC curve

uninformative. A true positive rate of 80% is associated with a false positive rate of 26%, which corresponds to a specificity of 74%. The AUC was 0.84 indicating that the regression model was providing reasonable prediction.

**5.3.4 Discussion**

Relatively few studies have been reported in the literature looking at accommodation in the short term following a hip fracture. All but one of the studies have used the place of discharge from the acute hospital as being the endpoint of interest. This has the inherent problem of not being a fixed time interval. Ceder et al (1980) in their cohort of 103 patients investigated the hospital discharge place of residence and the place of residence at three weeks post-fracture. These researchers only recruited patients who were resident in their own homes prior to their fracture as this is the study population with the most rehabilitation potential. In the current study one month accommodation was dichotomised into community and institutional residence as this is an important distinction to make for early supported discharge schemes which will be discussed more fully in the overview chapter.

**Table 5.4** Observed versus predicted accommodation

Predicted probability	Observed frequency			Observed probability
	Institution	Community	Total	
0.00-0.09	0	16	16	0.00
0.10-0.19	4	16	20	0.20
0.20-0.29	3	17	20	0.15
0.30-0.39	5	8	13	0.38
0.40-0.49	8	8	16	0.50
0.50-0.59	9	6	15	0.60
0.60-0.69	9	4	13	0.69
0.70-0.79	18	3	21	0.86
0.80-0.89	13	5	18	0.72
0.90-1.00	13	1	14	0.93

In the current study age was found to be the most important predictive factor for accommodation at one month post hip fracture at the multivariate level of analysis. This confirmed the multivariate findings of Dolk (1989), Ensberg et al (1993), and Sernbo and Johnell (1993). Wachtel et al (1987) also indicated the importance of age at a multivariate level in predicting return home of elderly patients using a cohort of general medical admission patients. Ceder et al (1980) reported a significant univariate association for age and discharge home in their hip fracture patients. This was also supported univariately by a recent Scottish study which looked at all elderly trauma patients admitted to an acute hospital (Currie and Tierney 1992). Van der Sluijs and Walenkamp (1991) however failed to demonstrate significance even at the univariate level of analysis for their hip fracture patients. The reason for this negative finding is not obvious.

The study by Thorngren et al (1993) is the only one in the literature to report a significant association with sex and discharge home at either the univariate or multivariate levels of analysis. In their study female sex was found to be an independent predictor of discharge home by three weeks post-fracture. The present study is in keeping with the main body of the literature. Age and fracture type were noted to confound gender in the multivariate analysis.

The pre-fracture place of residence did not predict the accommodation at one month post-fracture in the current study. Multivariately this was seen to be largely due to the confounding effect of age. This result was in line with the study by van der Sluijs and Walenkamp (1991). Few of the studies in the literature included patients in supported forms of care in the community or institutional care. Ensberg et al (1993) did however find that nursing home patients had a significantly shorter length of hospital stay on multivariate analysis.

Living with someone prior to the fracture was found to be an independent predictor of discharge from acute hospital in the current study and is supported by the work of Ceder et al (1980), Sernbo and Johnell (1993) and Thorngren et al (1993). In the



current study the highest rate of return to previous place of residence was for patients in supported forms of accommodation although the number of such patients was small. It was also noted that patients who were married had a significantly higher rate of return to the community at one month post-fracture but that this was confounded by age and was rendered non-significant in the multivariate analysis. Van der Sluijs and Walenkamp (1991) established a significant univariate association between co-residents and return to the community but this association was non-significant on multivariate analysis.

Fracture type was also found to be a significant predictor of returning to the community at one month in the present study. Patients who sustained an intracapsular fracture were 50% more likely to have returned to the community than patients who had sustained an extracapsular fracture. This result confirmed the findings by Ceder et al (1980), Campion et al (1987), Thorngren et al (1993) and Weatherall (1993(b)).

However van der Sluijs and Walenkamp (1991) found that similar proportions of intracapsular and extracapsular fracture patients were discharged home. Ensberg et al (1993) did not find fracture type to be predictive of short length of hospital stay.

Physical health is intuitively an important predictor of length of hospital stay and subsequent place of discharge. Ceder et al (1980) and van der Sluijs and Walenkamp (1991) both report an independent predictive effect of general health on early place of domicile. Univariate confirmation was obtained by Furstenberg and Mezey (1987). In the present study however self-rated general health, the number of medical conditions and the total number of categorised medical conditions did not even attain significance at the univariate level of analysis indicating that they were of little importance in the self-reporting group of patients.

In the current study the SRG of patients had a reasonably high level of baseline cognitive functioning as they had to have a pre-fracture AMT score of seven or more.

The study nonetheless managed to demonstrate that mental impairment was an independent predictor of accommodation at one month post-fracture. Van der Sluijs



and Walenkamp (1991) confirmed these findings using a similar study population to the current study for the place of discharge from the acute hospital. Ensberg et al (1993) noted the association at a univariate level only. Increased lengths of hospital stay have also been reported to be associated with dementia in general medical patients at a univariate level (Watchel et al 1987, Francis et al 1990) and at a multivariate level of analysis in hip fracture patients (Furstenberg and Mezey 1987).

The role of pre-fracture dependency measures in predicting future accommodation in the short term have not been widely reported in the literature. Part of this is attributable to the fact that most studies in the area have used a study population who were resident in their own homes prior to their fracture and therefore would be expected to have a reasonably high level of pre-fracture functioning. In addition to this some of the studies have restricted themselves to addressing the relationship of the activities of daily living at two to three weeks post-fracture to the place of discharge following a hip fracture (Ceder et al 1980, van der Sluijs and Walenkamp 1991).

In the current study greater independence as gauged by the variables 'how the patient rated how they managed on a daily basis', the Clackmannan score and the ability to do heavy shopping were all significantly related to return to the community at one month post-fracture at a univariate level. The first two also attained multivariate significance whilst the latter variable did not largely because it was confounded by 'how the patient managed on a daily basis'. It was interesting to note that just under 80% of patients who were able to do their own heavy shopping without difficulty returned to the community so it may have been expected to have been a predictor of short term accommodation. Better pre-fracture ADL levels were also significantly associated with an early hospital discharge but at a univariate level only in the study by Ensberg et al (1993). Watchel et al (1987) managed to attain a significant multivariate relationship between poor pre-hospitalisation ADL function and subsequent institutionalisation in their series of geriatric patients admitted to an acute medical ward. The ability to perform ADLs two to three weeks post-fracture was found to be

univariately associated with discharge to the community in the studies by Ceder et al (1980) and van der Sluijs and Walenkamp (1991) but failed to reach multivariate significance.

It was interesting to note that dependency as measured by the Barthel Index failed to achieve univariate significance in the current study using the self-reporting group of patients. This is probably largely attributable to the ceiling effect that is well recognised with the Barthel Index. It would have been a particular problem for the SRG of patients as their baseline level of functioning on the whole was reasonable and they would have scored very highly on the Barthel scale as fairly gross impairment is required before it is registered. The Clackmannan mobility subscale is more graded and comprehensive than the Barthel mobility subscale. It includes the ability to walk outside as well as the ability to get on to a bus. The self-care subscale incorporates less basic tasks than the Barthel self-care subscale and does not have the same emphasis on incontinence. Consequently the Clackmannan scale is probably more discriminatory for a group of patients who are mostly in their own homes prior to their fracture.

The type of help required pre-fracture has also been reported to be an independent predictor of home discharge in the study by Dolk (1989) using an unselected series of patients with intracapsular fractures but not for patients with an extracapsular fracture. In the current study a significant univariate association was obtained for the type of main helper and accommodation status at one month post-fracture. Watchel et al (1987) also documented a significant univariate association with their series of general medical patients. Ceder et al (1980) failed to establish a univariate relationship between pre-fracture home help and discharge home.

The ability to visit someone prior to the fracture was found to be significantly associated with accommodation at one month post-fracture at a univariate level in the current study and this has also been reported by Ceder et al (1980). However the reliance on walking aids pre-fracture was not found to be associated with one month

accommodation in the present study. Ensberg et al (1993) noted a univariate relationship with the ability to climb stairs pre-fracture and discharge. Ceder et al (1980) reported that walking ability two weeks post-fracture was predictive of discharge and van der Sluijs and Walenkamp (1991) confirmed this at a univariate level only.

In summary, a younger age, greater independence, the presence of co-residents and an intracapsular fracture were independently predictive of an early return home in the SRG of patients which supports the published literature. It was not anticipated however that none of the general health measures would attain univariate significance whilst cognitive functioning would achieve multivariate significance. These findings contrast with the main body of literature. This is the first study to highlight the greater sensitivity of the Clackmannan scale in detecting dependency compared to the widely employed Barthel Index. The regression model provided reasonable prediction for place of residence at one month post-fracture as indicated by an AUC of 0.84.

#### **5.4 ONE MONTH DEPRESSION FOR SELF-REPORTING GROUP**

Depression was only assessed in patients in the self-reporting group as meaningful assessment of depression in patients with impaired cognition is difficult. Furthermore, research performed by Burke et al (1989) has suggested that the Geriatric Depression Scale (GDS), which is the instrument recommended by the joint working party of the RCP and BGS to assess depression, is not valid in patients with dementia.

There are no published figures on the validity and reliability of the short version of the GDS but a cut-off point of five has been suggested as representing probable depression (RCP and BGS 1992). Study patients were dichotomised into 'depressed' and 'non depressed' groups using the recommended cut off point with a score of more than five indicating depression. The total GDS score was also analysed as a continuous variable at one month post-fracture to gauge whether outcome assessed in this way would be more useful. Reservations about the clinical usefulness of the short form of the GDS have been outlined in section 4.7.5.2.

152 patients were available for the one month depression analysis. Eight of the 166 self-reporting patients who participated in the baseline interview had died within 30 days of being admitted to hospital with their fracture. One patient was excluded from the analysis as a result of a severe intervening medical illness, one patient was in South Africa, one patient required a proxy due to a deterioration in her mental state, one patient was moribund and two patients refused to complete the psychological component of the one month interview.

#### **5.4.1 Univariate Analysis**

The important univariate analysis results are summarised in Appendix 10. The one month GDS score was classified as a binary variable for the analysis to be in keeping with the recommendations by the RCP and the BGS (1992).

None of the basic demographic variables were significantly associated with being depressed at one month post-fracture whilst poorer self-rated health and more medical conditions were. Baseline depression and a low morale, as indicated by a low PGCMS score, were very highly significantly related to being depressed at one month post-fracture, as would have been anticipated, but cognitive impairment was not. Increased pre-fracture dependency as indicated by the Barthel and Clackmannan scores and the mobility parameters were very highly significantly related to depression one month after the hip fracture. The social parameters did not have any consistent relationship to depression in the short term. If someone relied on the patient for help prior to their fracture then the patient was significantly less likely to be depressed at one month post-fracture. The frequency of attendance of religious events did not attain univariate significance with one month depression.

#### **5.4.2 Multivariate Analysis**

Two multivariate analyses were performed. A logistic regression analysis was undertaken with one month depression treated as a binary variable. One month depression was also analysed as a continuous variable using multiple regression.



#### **5.4.2.1 Selection of First Line Variables**

No study has been reported in the literature which has looked at the predictors of depression in the short term following a hip fracture. As a result of this the selection of first line variables has been guided by the results of studies which have looked at factors associated with depression in general populations. The analyses in these studies have only been performed at a univariate level.

The basic demographic variables age, sex and marital status have been reported in the literature as being associated with depression so they were all included as possible first line predictor variables of depression at one month post hip fracture in the current study (Murrell et al 1983). Similarly, the association between health and depression has been noted so the variables general health and 'the number of categorised medical conditions' were also included in the present study (Frerichs et al 1982, Murrell et al 1983). The baseline GDS score and the PGCMS score were included as potential predictors for self-evident reasons. The level of the patients baseline dependency was also considered to be potentially important in predicting future depression. The total Barthel score, the main helper as well as the number of pre-fracture services required were all used as first line variables to cover this area. Support at home was also considered to be a possible predictor of future depression and the main helper was used as an indicator variable for this. The literature suggests that sustaining an extracapsular fracture is associated with a poorer outcome (Ceder et al 1980, Campion et al 1987, Thorngren et al 1993, Weatherall 1993). As a poorer outcome may intuitively influence affective state fracture type was included as a potential first line predictor.

#### **5.4.2.2 Logistic Regression**

The logistic regression model being fitted is for the probability of not being depressed at one month post-fracture.



**5.4.2.2.1      First Line Variables in the Regression Model**

Only two of the first line variables attained the 10% significance level required to be entered into the ordered logistic model. The first variable to be added to the model was the total GDS score at baseline as may have been anticipated. This was followed by the self-rated general health of the patient. Individuals who scored worse on the depression scale or who had poorer general health were significantly more likely to be depressed at one month post-fracture. The regression model is presented in Table 5.5.

This model was substantiated by the fact that it was also obtained using the backward step-wise procedure.

**Table 5.5** One month logistic regression analysis for non-depressed state

**A.      FIRST LINE PREDICTOR VARIABLES**

**1.      Forward stepwise regression**

a)      Significant variables			
Variable	Coefficient	Standard error	P
Intercept	1.47	0.83	-
Total GDS score	-0.49	0.094	0.0001
General health	0.31	0.18	0.076

b)      Non-significant variables	
Variable	P
Age	0.68
Sex	0.70
Marital status	0.54
Managed on a daily basis	0.24
Total number of categorised medical conditions	0.68
Total Barthel score	0.49
Total PGCMS score	0.20
Fracture type	0.54
Main helper	0.86

**2.      Backward stepwise regression**

Same regression model generated as from forward procedure.

**Table 5.5 (continued)** One month logistic regression analysis for non-depressed state**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	1.24	0.86	-
Total GDS score	-0.49	0.10	0.0001
General health	0.30	0.18	0.10
Others rely on patient for help	1.66	0.63	0.0086

**5.4.2.2.2 Final Regression Model**

Only one second line variable, namely whether anyone relied on the patient for help, entered the logistic model at the 5% level of significance. Patients who had someone that needed their help were significantly less likely to be depressed. No further additions were made to the model when the third line variables were entered. The final regression model is presented in Table 5.5 and is summarised here :

$y = 1.24 + (0.30 \times \text{general health}) - (0.49 \times \text{total GDS score}) + (1.66 \times \text{someone relied on patient for help})$

Reviewing the coefficients for the predictor variables in the logistic regression model revealed that there was an odds ratio of 0.62 of not being depressed at one month for each point towards a zero score on the 15 point scale of the GDS score. For each increment towards very good health on the five point general health variable scale patients had a 1.35 odds ratio of not being depressed. If the patient had someone who relied on them for help before their fracture then they had an odds ratio of 5.25 of not being depressed at one month post-fracture compared to a patient that had no-one rely on them.

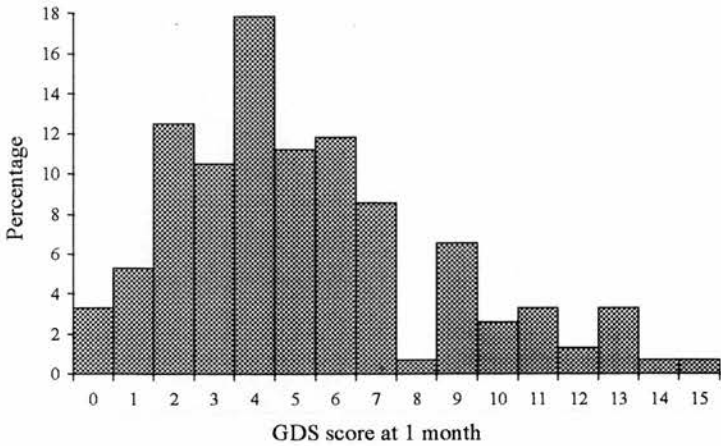
**5.4.2.3 Multiple Regression**

The total GDS score was also analysed as a continuous variable to gauge whether this would confer any additional benefit for predictive purposes over a binary classification. A review of the distribution of the total GDS scores revealed that it was not normally distributed. See Figure 5.3. The transformation that minimised the

skewness of the distribution was the square root of (total GDS score + 1) and this variable was used for the multiple regression analysis. See Figure 5.4.

A plot of the raw values of the baseline GDS score against the transformed one month GDS score revealed that the association was essentially linear. On this basis, coupled with the fact that it would be easier to

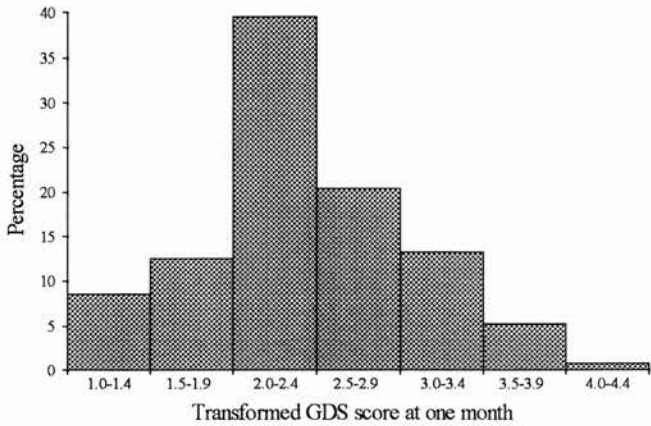
use the raw baseline GDS scores in a prognostic index, the decision was made not to transform the baseline GDS score for the multiple regression analysis.



**Figure 5.3** One month Geriatric Depression Scale scores

**5.4.2.3.1**      First Line Variables in the Regression Model

Three baseline variables entered the regression model at the 10% level of significance. Refer to Table 5.6. The importance of baseline psychological variables in predicting future depression was clearly indicated by the total GDS score and the total PGCMS



**Figure 5.4** One month transformed Geriatric Depression Scale scores

score entering the model. These two terms were followed by general health. Patients who had a more positive affective state and were in better general health were less likely to be depressed at one month post-fracture.

**Table 5.6** One month depression multiple regression analysis

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

**a) Significant variables**

Variable	Coefficient	Standard error	P
Intercept	1.93	0.18	-
Total GDS score	0.11	0.017	0.0001
Total PGCMS score	0.032	0.014	0.022
General health	-0.074	0.034	0.034

**b) Non-significant variables**

Variable	P
Age	0.44
Sex	0.67
Marital status	0.77
Managed on a daily basis	0.42
Total number of categorised medical conditions	0.84
Total Barthel score	0.29
Main helper	0.14
Fracture type	0.86

**2. Backward stepwise regression**

Same model generated as with the forward stepwise procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	2.13	0.19	-
Total GDS score	0.10	0.016	0.0001
Total PGCMS score	0.025	0.013	0.054
General health	-0.028	0.034	0.42
Optimism about mobility	-0.084	0.031	0.0075
Others rely on patient for help	-0.22	0.073	0.0037
Outside walking aid	0.029	0.013	0.030
Frequency of church attendance	0.0091	0.0045	0.045

The same regression model was obtained using a stepwise backward procedure indicating that the model was robust.

#### **5.4.2.3.2      Final regression model**

Four further baseline variables attained independent significance at the 5% level. These variables in the order in which they entered the model were : optimism regarding future walking, whether someone relied on the patient for help, outside walking aid, and the frequency of attending religious events. It should be noted that vision entered the model as a significant second line variable but that its coefficient had the 'wrong' sign. The second line regression analysis was re-run without vision in it and this was when the 'frequency of attending religious events' variable was added into the model. Patients who were more optimistic about their walking ability, had someone who relied on them for help, had less impairment of their walking ability and attended church more frequently were significantly less likely to be depressed. No third line variables attained the 1% level of significance required for entry.

The final regression model was :

$$y = 2.13 - (0.028 \times \text{general health}) + (0.10 \times \text{total GDS score}) + (0.025 \times \text{total PGCMS score}) - (0.084 \times \text{optimism about walking}) - (0.22 \times \text{someone relies on the patient for help}) + (0.029 \times \text{outside walking aid}) - (0.0091 \times \text{frequency of church attendance})$$

The model explained 56% of the variance which is a high value when dealing with biological data. It represents a multiple correlation coefficient of 0.75.

#### **5.4.2.4      Comparison of Regression Models**

All three of the significant baseline predictor variables obtained with the logistic regression procedure appeared in the model obtained using the stratified multiple regression approach. The latter procedure added in a further four baseline variables which is directly attributable to its higher power which arises from the fact that it uses the actual numerical values whilst the logistic regression analysis simply uses the outcome data in a binary form. This is important if there is a linear or at least a



monotonic relationship, rather than a stepwise relationship which is implicitly implied by fitting it as a binary outcome.

5.4.3 Prediction in Practice

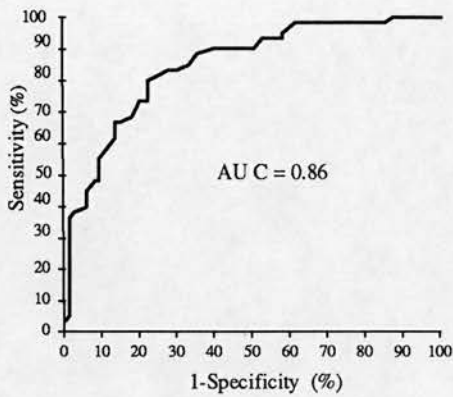
The joint working party of the RCP and BGS recommended that depression was treated as a binary variable based on the score derived from the GDS scale. As a direct result the two clinical examples which follow will use the logistic regression model to determine the probability of depression at one month post-fracture. If a patient was in very good health prior to his/her fracture and someone relied on him/her for help and their GDS score at the time of their initial interview was one then his/her probability of being depressed at one month post-fracture may be calculated to be 0.08 using the approach outlined in section 5.2.3. If however the patient was in poor general health, no-one relied on him/her for help and their baseline GDS score was seven then the probability of depression at the same stage was 0.83.

Table 5.7 shows the estimated probabilities of being depressed against what was actually observed when depression was analysed as a binary variable. The predicted and the observed probabilities roughly approximate each other.

Table 5.7 Predicted versus observed one month depression

Predicted probability	Observed frequency			Observed probability
	Depressed	Not depressed	Total	
0.00-0.09	1	25	26	0.04
0.10-0.19	5	21	26	0.19
0.20-0.29	3	16	19	0.16
0.30-0.39	7	10	17	0.41
0.40-0.49	7	8	15	0.47
0.50-0.59	7	4	11	0.64
0.60-0.69	4	3	7	0.57
0.70-0.79	6	4	10	0.60
0.80-0.89	5	0	5	1.00
0.90-1.00	15	1	16	0.94

The usefulness of the logistic regression model is presented graphically in Figure 5.5 and can be seen to be reasonable with an AUC of 0.86. To illustrate the diagnostic capability of the regression model a sensitivity of 80% for example is associated with a specificity of 79%. In other words, there is an 80% chance of correctly predicting depression and a 79% chance of correctly predicting a non-depressed state.



**Figure 5.5** One month depression ROC curve

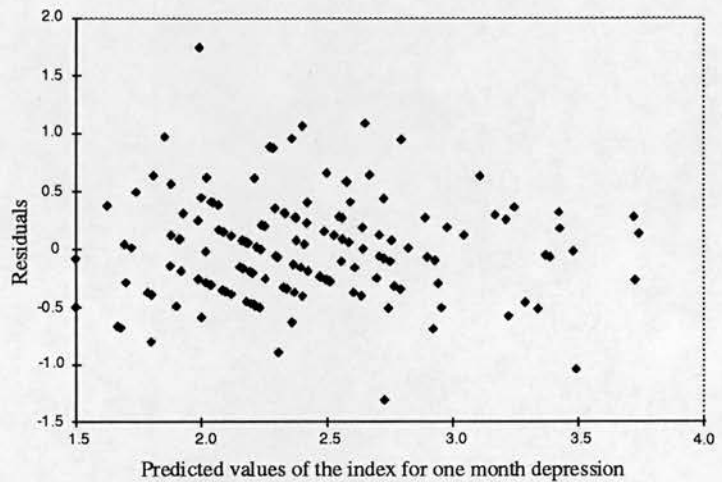
Figure 5.6 shows the graph of the residuals from the multiple regression model plotted against the predicted values of the index for depression. This graph is looking at the assumptions of the regression model that the residuals are identically and normally distributed. The residuals should not depend upon the value of the index or any of the values for any of the independent components of the index. Figure 5.6 shows that there is

no evidence that the errors were dependent on the predicted values and there were no gross outliers thereby

indicating that the assumptions of the regression model were met.

Furthermore there was no evidence of non-linearity for any of the predictor variables when the residuals were plotted against the values of the predictor variables.

These dot plots have not been presented.



**Figure 5.6** Residual plot for predicted values of index for one month depression

#### 5.4.4 Discussion

Given that the reliability and the validity of the short form of the GDS as a measure of depression have not been established, and that depression status as gauged by the GDS score was found to correlate poorly with clinically treated depression in the EHFS patients at the time of their fracture, as outlined in section 4.7.5.2, means that the use of the GDS to assess the presence of depression should be interpreted with

caution. This has implications for the usefulness of the predictors derived in the EHFS for depression as defined by the GDS.

In the present study pre-fracture psychological variables and physical health were found to be predictive of depression one month following a hip fracture. The baseline variables total GDS score, self-rated general health and 'whether anyone relied on the patient for help' were predictive of one month depression when it was analysed as both a binary and a continuous variable. It was interesting to note that pet ownership did not enter the regression model although human dependency did as just outlined. In the multiple regression analysis additional predictor variables were obtained, these being total PGCMS score, optimism about walking again, type of outside walking aid required and the frequency of attendance of religious events. It was interesting to observe that the frequency of attendance at religious events was not significant at a univariate level but managed to achieve independent significance. This was due to it being confounded by the total baseline GDS score. The analysis performed for one month depression with the total GDS as a continuous variable had greater power than when it was analysed as a binary variable. This suggests that the numerical values for the GDS are informative, and that a dichotomy into 'depressed' and 'non-depressed' may be too simple. Nonetheless, the logistic regression model provided reasonable prediction as indicated by an AUC of 0.86.

A comparison of the predictor results for one month depression in the present study with the results from other hip fracture studies investigating the determinants of depression was not possible because none have been reported in the literature. Intuitively however it would be expected that psychological variables would be predictive of the development of future depression and this was indeed found in the current study with five of the seven predictor variables being of this nature. Physical health has also been noted to be associated with depression in general populations and the current study confirms this association (Frerichs et al 1982, Murrell et al 1983). A relationship between pre-fracture walking dependency and depression at one month post-fracture also seems to be plausible.

## **5.5 ONE MONTH DEPENDENCY**

Dependency in the current study was assessed with the Barthel Index which is widely used in rehabilitation medicine. The joint working party of the Royal College of Physicians and the British Geriatrics Society in 1992 suggested that the Barthel Index should be classified in a clinically meaningful way for comparative use rather than using it as a continuous variable. This suggestion arose because of the fact that the Barthel Index does not use an interval scoring system. This means that a change in one point at the upper end of the scale is not equivalent to a change in one point at the lower end of the scale. However it was recognised by the joint working party that further research was required to establish the usefulness of this approach. As a direct result of this it was decided to perform two different types of analyses for functional outcome at twelve months post-fracture. Refer to section 6.5. An ordered logistic regression was employed when the 12 month total Barthel score was categorised and a multiple regression procedure was used when the 12 month total Barthel score was analysed as a continuous variable. For one month dependency the total Barthel score was analysed as an ordered categorical variable only.

The groupings used for the ordered logistic regression analyses for one month dependency were guided by the RCP and BGS report (1992). A cut off point of 12 out of 20 has been used to dichotomise individuals into dependent and independent groups. Within the dependent group it has been suggested that a score of eight or less may serve to indicate severe dependence whilst one of four or less suggests total dependence. In addition to these recommendations consideration was also given to the actual distribution of the total Barthel scores at one month post-fracture for the self-reporting group and the whole study cohort. Further categorisation of the independent group occurred based on the number of patients with a particular Barthel score. This further subdivision permits better discrimination of outcome to be achieved. Different classifications were subsequently used for the SRG of patients and the whole study cohort based on the distribution of their Barthel scores and are detailed at the start of sections 5.5.1 and 5.5.2 respectively. The classifications were used for both the univariate and multivariate analyses.

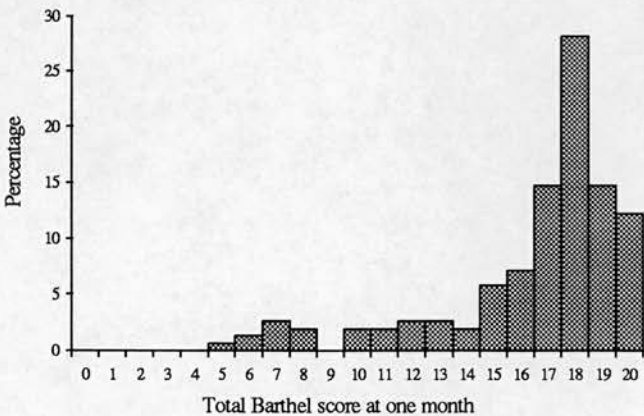


The decision was taken to analyse the dependency outcome variable for both the SRG and the whole study population. The reason for analysing the SRG separately was because the total Barthel score gives an objective measure of dependency and consequently may be of use for identifying criteria for the Early Supported Discharge Schemes. This would supplement the predictive factors derived for placement at one month post-fracture which to a large extent are influenced by management practice.

In this section the results for the SRG of patients will precede that for the whole study population. One patient in the SRG was excluded from both analyses on the basis of a severe intervening medical event which interfered with her rehabilitation. Additionally the dependency data for the patient who had gone to convalesce in South Africa was not available, and there were eight deaths in the SRG group and 11 in the IRG. In total 156 patients were available for the SRG dependency analysis and 249 for the whole study dependency analysis.

**5.5.1 Self-reporting Group**

The distribution of the total Barthel scores in the self-reporting group was markedly skewed to the left. Only 16 (10%) of the individuals in this group had scores of less than 12 so it was not reasonable to subdivide this dependent group any further.



**Figure 5.7** One month Barthel Index score for self-reporting group

Numbers allowed the independent group to be subdivided into four categories.

The Barthel scores for these groups were 12 to 16, 17 to 18, 19 and 20 and the number of patients within these groups were 31, 67, 23 and 19 respectively. See Figure 5.7.



### **5.5.1.1      Univariate Analysis**

The important univariate analysis results are presented in Appendix 10. None of the basic demographic baseline parameters were significantly associated with dependency at one month post-fracture. Patients who had sustained an extracapsular fracture were twice as likely to be dependent one month later but this did not attain significance at the univariate level with the low number of dependent patients. All of the measures of physical and mental health, except for the number of hospitalisations in the year preceding the fracture and morale as gauged by the PGCMS, were significantly related to dependency at one month post-fracture. Highly significant associations were observed with the mobility and the self-care baseline parameters and the one month total Barthel score. This was expected as the total Barthel score is comprised of a mobility and a self-care subscale. Other variables reflecting dependency, namely 'how the patient managed on a daily basis' and the number of health and social services required also achieved significant univariate relationships with the one month Barthel score. The only other social parameter to reach significance with one month dependency was the frequency of social events attended.

### **5.5.1.2      Multivariate Analysis**

An ordered logistic regression analysis was performed using the groupings outlined in the univariate analysis.

#### **5.5.1.2.1      Selection of First Line Variables**

Only four studies have reported the short term functional outcome in a standardised way in hip fracture patients (Barnes and Dunovan 1987, Broos et al 1988, Borkan and Quirk 1992, Marottoli et al 1992). Within these studies the study populations, the criteria for assessing functional outcome and the timing of the assessment itself have not been consistent making direct comparisons difficult. The most comprehensive of the studies that have been performed to date is that by Marottoli et al (1992) and formed the basis for selecting the first line potential predictor variables for the current study. This study assessed functional outcome at six weeks post-fracture which was comparable to the timing of assessment performed in the current study and used

multivariate statistical techniques. The only other study to report multivariate associations was the one performed by Borkan and Quirk (1992).

Age was included as a potential predictor for short term functioning in the current study because of its basic epidemiological importance. Significant statistical associations have been reported by Barnes and Dunovan (1987), Broos et al (1988) and Marottoli et al (1992). Gender was similarly included in the present study although the two studies which have investigated this variable failed to find a significant association (Broos et al 1988, Marottoli et al 1992). The findings for the pre-fracture place of accommodation in relation to short term physical functioning are not consistent but this variable was nonetheless included as a predictor variable in the current study because of its intuitive importance (Barnes and Dunovan, Broos et al 1988, Marottoli et al 1992). Borkan and Quirk (1992) have reported an association between having had a previous major illness or injury and the amount of subsequent impairment but no other significant association for comorbidity has been reported (Broos et al 1988, Marottoli et al 1992). In the current study self-rated general health and the 'total number of categorised medical conditions' were included as potential first line predictors to cover general health. Patients with better cognitive functioning and higher expectations for recovery have been reported to have had a greater physical recovery (Borkan and Quirk 1992, Marottoli et al 1992). The total AMT score and the total GDS score were incorporated into the analysis for the current study to cover the role of cognition and affective state. The findings for pre-fracture functional status in relation to function at six weeks post-fracture are not consistent in the literature (Broos et al 1988, Marottoli et al 1992). The baseline Barthel score and the inside walking aid were incorporated into the present study to cover physical functioning in order to investigate the association between baseline function and future function. Dependency was further assessed in the current study by including a variable denoting the patient's main helper prior to their fracture. Fracture type has not been found to be predictive of short term functional outcome but was nevertheless included in the present study because of its potential importance (Broos et al 1988, Marottoli et al 1992).

### 5.5.1.2.2 First Line Variables in the Regression Model

Five first line variables were added into the ordered logistic regression model when a forward step-wise procedure was used and are shown in Table 5.8. The first of these was the baseline total Barthel score, as may have been anticipated, followed by fracture type, how the patient managed on a daily basis, age and self-rated general health. Patients who at the time of their fracture were younger, had better health, were less dependent or who had sustained an intracapsular fracture were significantly more likely to be less dependent at one month post-fracture.

**Table 5.8** One month dependency ordered logistic regression analysis for self-reporting group

Λ. FIRST LINE PREDICTOR VARIABLES

1. Forward stepwise regression

a) Significant variables			
Variable	Coefficient	Standard error	P
Intercept 1	0.32	2.37	-
Intercept 2	2.02	2.39	-
Intercept 3	4.29	2.40	-
Intercept 4	5.44	2.40	-
Total Barthel score	-0.39	0.10	0.0001
Fracture type	0.89	0.31	0.0046
Managed on a daily basis	0.42	0.24	0.081
Age	0.044	0.020	0.023
General health	-0.23	0.14	0.10

b) Non-significant variables	
Variable	P
Sex	0.40
Accommodation	0.88
Total number of categorised medical conditions	0.90
Total GDS score	0.62
Total AMT score	0.22
Inside walking aid	0.37
Main helper	0.32

2. Backward stepwise regression

Same regression model generated as from forward procedure.

**Table 5.8 (continued)** One month dependency ordered logistic regression analysis for self-reporting group

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-2.47	2.46	-
Intercept 2	-0.70	2.47	-
Intercept 3	1.69	2.46	-
Intercept 4	2.87	2.45	-
Total Barthel score	-0.23	0.10	0.022
Fracture type	1.01	0.32	0.0014
Managed on a daily basis	0.28	0.25	0.25
Age	0.035	0.020	0.076
General health	-0.24	0.14	0.082
Outside walking aid	0.22	0.07	0.0026

The stability of the ordered logistic regression model derived from entering the first level baseline variables in a forward step-wise procedure was verified when the same regression model was obtained using a backward step-wise approach.

**5.5.1.2.3 Final Regression Model**

Adding in the second line variables in a forward stepwise procedure resulted in the outside walking aid being included into the model. The outside walking aid variable confounded the first line variable 'how the patient managed on a daily basis' with as evidenced by its probability rising from 0.081 to 0.25. The second line variable which measured whether the patient was able to manage on their own for more than a couple of hours had an independent significance level of 0.052 in the regression model. It was not included in the final model however as only four patients out of the 156 were deemed not able to look after themselves for more than two hours so consequently the variable was of limited use. No further variables were added into the model when the third line variables were included. The final regression model is presented in Table 5.8 and is also given here :



$y = \text{intercept} + (0.035 \times \text{age}) - (0.24 \times \text{general health}) + (0.28 \times \text{managed on a daily basis}) - (0.23 \times \text{total Barthel score}) + (0.22 \times \text{outside walking aid}) + (1.01 \times \text{fracture type})$

The numerical values used in this formula for each of the categorical variables are shown in Appendix 11. The odds ratio for each of the predictor variables can be calculated from the ordered logistic regression model for any dichotomy of the outcome variable. Thus, as a result of the structure of the ordered logistic regression model, it may be estimated that for any predictor variable the odds ratio will be the same for a split of the Barthel score into dependent and independent, as for a split into a score of 19 or less versus 20. Sustaining an extracapsular fracture compared to an intracapsular fracture had the greatest impact on the odds ratio of moving into a more dependent category with this being 2.75. This was followed by age where every decade increment was associated with a 1.42 times increase in the odds ratio. Every point decline in the four point variable 'how the patient managed on a daily basis' was associated with a 33% increase in the odds ratio of moving into a more dependent functional category as gauged by the total Barthel score. The increase in odds ratios for moving into a more dependent category for each unit change representing deterioration in the variables general health, total Barthel score at baseline and outside walking aid were all very similar, these being 28%, 26% and 24% respectively. The number of categories in each variable were 5, 21 and 9 respectively.

#### **5.5.1.3 Prediction in Practice**

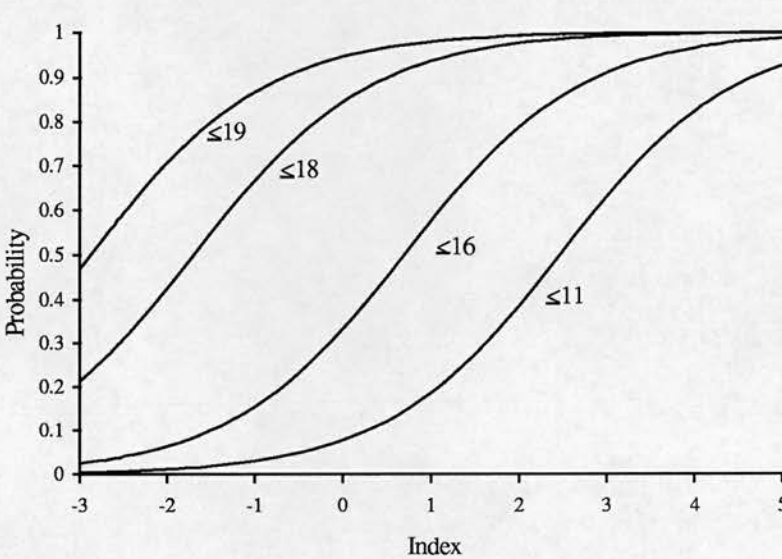
Four values for the intercept term in the ordered logistic regression model were generated corresponding to the fact that the one month total Barthel score was classified into five categories. This meant that four parallel lines on the logistic scale were generated. See Table 5.8. This is the standard way in which ordered logistic regression models are presented so that the results are more easily interpretable. The probability of being in a particular category, or a lower one, is then calculable using  $p = e^y / (1 + e^y)$ . To calculate the probability of being in category 1, that is having a score of 11 or less, the intercept -2.47 is used. To be in category 2 or less, that is



having a score of 16 or less, the intercept -0.70 was used. The intercepts 1.69 and 2.87 were used for Barthel scores of less than 19 and 20 respectively.

The form of summary presentation for an ordered categorical variable such as the total Barthel score needs to be different from that for a binary outcome, such as mortality, as the simple calculation of probability of being in one of two categories no longer applies. What is important is the rankings of individuals from highest to lowest risk and this can be achieved by calculating an index value for each patient which consists of the previous expression for y but with the intercept term omitted. In other words the index equals  $(0.035 \times \text{age}) - (0.24 \times \text{general health}) + (0.28 \times \text{managed on a daily basis}) - (0.23 \times \text{total Barthel score}) + (0.22 \times \text{outside walking aid}) + (1.01 \times \text{fracture type})$ . The probability of a dependency grade for any given patient having derived their index value from the

ordered logistic regression model



**Figure 5.8** One month dependency sigmoid curves for self-reporting group

may be done quite simply if the index is plotted against the probability of dependency as shown in Figure 5.8. The four curves represent the four formulae obtained from the ordered logistic regression analysis. For any value of the index from Figure 5.8 the predicted probabilities of scores less than or equal to 11, 16, 18 and 19 may be read off. Thus for an individual who was 72 years of age in good general health who managed on a daily basis with just a little difficulty but scored full marks on the Barthel Index and who could walk outside unaided prior to her fracture and who had sustained an extracapsular fracture her index value can be calculated to be -0.98 by inserting the appropriate values into the index formula. The numerical values used in

this calculation for each of the categorical variables are shown in Appendix 11. From Figure 5.8 her probability of having a total Barthel score at one month post-fracture of less than or equal to 11, 16, 18 and 19 can be seen to agree with values of 0.027, 0.16, 0.66 and 0.86 respectively which can be calculated directly from the formula.

**Table 5.9** Prognostic index value cross-tabulated against observed one month dependency for self-reporting group

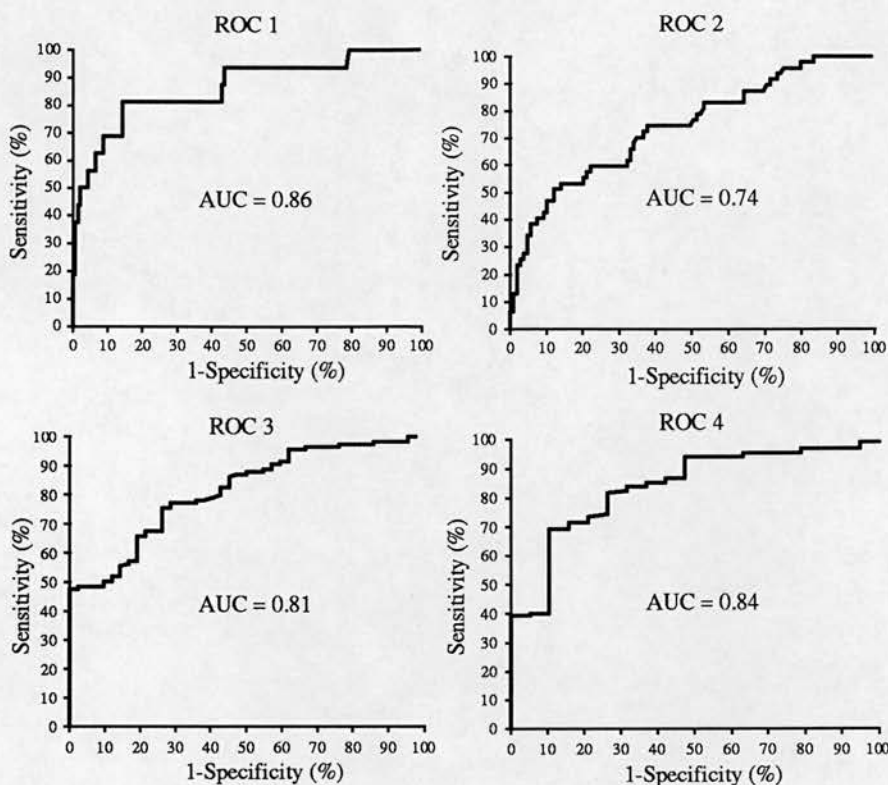
Index	Observed frequency for Barthel score					Total
	0-11	12-16	17-18	19	20	
-3.00-<-2.01	0	0	4	3	7	14
-2.00-<-1.01	1	10	18	11	10	50
-1.00-<-0.01	2	7	21	9	2	41
0.00-<0.99	2	7	16	0	0	25
1.00- 1.99	3	5	6	0	0	14
2.00- 2.99	5	1	1	0	0	7
3.00- 3.99	2	0	1	0	0	3
4.00- 4.99	1	0	0	0	0	1

In Table 5.9 the regression model index is cross tabulated against the observed category for the Barthel score to gauge how well it predicts

dependency. It can be readily seen that the low values of the index correspond to less dependency as indicated by a higher Barthel score. A Spearman's correlation coefficient of -0.55 was obtained when a correlation analysis was performed relating the index value to the categorised total Barthel score at one month post-fracture which indicates a close association between the two variables. This result was anticipated as the same data set was used to generate each of the variables. The agreement between observed percentages within categories of dependency and the corresponding predicted probabilities can be illustrated using the 72 year old patient in the previous paragraph with an index value of -0.98. Taking the patients with indices between -2 and 0 the observed proportions with a Barthel score of less than or equal to 11, 16, 18 and 19 are 0.003, 0.22, 0.65 and 0.87 respectively, from Table 5.19, which are similar to the estimated probabilities of 0.03, 0.16, 0.66 and 0.86.

Graphically the usefulness of the regression model can be presented as a series of ROC curves each representing the probability of being in a particular category or any above it versus being in any of the categories below it. Four ROC curves were consequently constructed for the total Barthel score at one month post-fracture as

there were five categories as shown in Figure 5.9. The AUC for the series of ROC curves ranged from 0.74 to 0.86. The best prediction for one month dependency was



**Figure 5.9** One month dependency serial ROC curves for self-reporting group

obtained for patients in the dependent category, that is a total Barthel score of 11 or less, versus the independent category, that is a score of 12 or more. The poorest prediction was obtained for patients with Barthel Scores of 16 or less versus 17 or more. To illustrate the predictive capacities of the two curves, a sensitivity of 80% was associated with specificities of 86% and 47% respectively. In other words, an 80% chance of correctly identifying greater dependency was associated with an 86% and 47% chance respectively of correctly predicting greater independence.

#### 5.5.1.4 Discussion

The independent effect of advanced age in predicting greater deterioration in physical functioning at one month post-fracture in the present study confirms the research by Marottoli et al (1992). Barnes and Dunovan (1987) and Broos et al (1988) reported a statistically significant relationship at the univariate level. However it was not

obvious in the current study why age was not significantly univariately related to the total Barthel score at one month post-fracture yet appeared as a significant predictor in the multivariate analysis. The univariate significance in the EHFS was 0.62 and the multivariate significance level was 0.076. Correlations of age with the baseline total Barthel score and with the change in Barthel score between baseline and one month were also not strong. The lack of predictive value of gender on one month dependency in the present study confirmed the negative findings by Broos et al (1988) and Marottoli et al (1992). In the present study pre-fracture accommodation amongst community-residing individuals was not found to be predictive of the level of physical functioning at one month post-fracture. This contrasts with the findings of Marottoli et al (1992) who reported that supported care within the community was associated at a univariate level with increased dependency at one month post-fracture. This association did not however hold at a multivariate level of analysis.

In the present study poorer self-rated general health was independently predictive of increased dependency at one month post-fracture. Two other indicators of comorbidity, namely the 'total number of categorised medical conditions' and the 'total number of medical conditions', reached univariate significance but failed to achieve multivariate significance. The studies by Broos et al (1988) and Marottoli et al (1992) failed to even establish a univariate relationship with functional dependency in the short term following a hip fracture and baseline comorbidity. It was interesting to note that in the study by Borkan and Quirk (1992) patients who had had a previous major illness or injury in the past started from a lower functional level but their subsequent functional decline following their hip fracture was significantly less at a multivariate level.

The evidence for pre-fracture cognitive functioning as having a direct influence on dependency levels following a hip fracture in the short term is firmer than that for physical health. In the current study the AMT score, the GDS score and PGCMS score all reached a univariate level of significance with one month dependency although all failed to achieve independent significance. Marottoli et al (1992) showed



that patients with pre-fracture mental impairment had a significantly poorer functional outcome at six weeks post-fracture at a multivariate level. These researchers however failed to find a univariate association with depression. Borkan and Quirk (1992) established that patients who had a more positive outlook on their rehabilitation potential were significantly less functionally impaired three months after their fracture at a multivariate level.

In the present study a general dependency variable 'how the patient managed on a daily basis' was found to be independently predictive of dependency at one month post-fracture. Additionally higher pre-fracture levels of dependency as gauged by the total Barthel score were found to be independently predictive of increased dependency as would have been anticipated. As the Barthel Index is comprised of mobility and self-care subscales it was not surprising to find that a baseline walking parameter, namely outside walking aid, also attained multivariate significance with dependency. Patients who required pre-fracture assistance with walking outside had an increased level of dependency at one month post-fracture. The mobility parameters were closely associated with each other and the confounding effect was made explicit in the multivariate models. The baseline self-care variables on the other hand whilst being very highly significantly related to one month dependency at a univariate level failed to achieve multivariate significance. The role of pre-fracture dependency in predicting subsequent dependency in the short term following a hip fracture is not well documented in the literature. Marottoli et al (1992) reported a significant univariate relationship between baseline physical functioning and function at six weeks post-fracture whilst Broos et al (1988) failed to establish a significant univariate relationship.

Patients in the current study who sustained an extracapsular fracture were significantly more likely to be dependent at one month post-fracture at a multivariate level. This is a new finding as Broos et al (1988) and Marottoli et al (1992) failed to find a univariate association with fracture type.

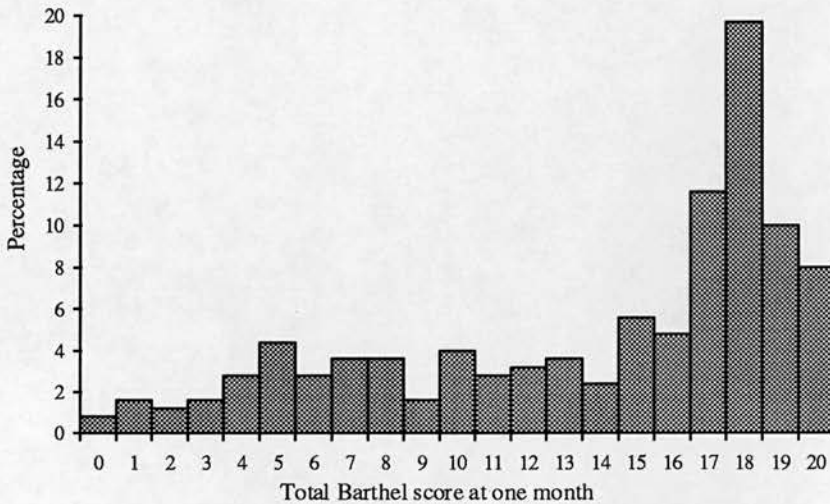


In section 5.3.3 the use of the regression model for one month accommodation in predicting patients who were suitable for the Early Supported Discharge Scheme was outlined. The baseline predictors obtained for the model in part however reflected the management practice that was in place at the time the EHFS was being conducted. Dependency, as gauged by the Barthel Index at one month post-fracture may therefore be a more objective measure of the suitability of patients for early return to the community though it is recognised that factors other than dependency affect the suitability of a patient for early discharge. There was overlap for the predictors obtained for accommodation and dependency at one month post-fracture for the SRG of patients. Age, 'how the patient managed on a daily basis' and fracture type were variables common to both outcome variables. Mental and social factors as well as self-care were important for prediction of accommodation whilst variables reflecting general physical health and frailty were more important for the prediction of dependency at one month. Both regression models need validation on an independent data set as the usefulness of the models will be overestimated if they are validated on the data set from which they were derived. It may well be that dependency correlates more strongly with residential status at one month post-fracture in an independent cohort of hip fracture patients than does the residential status predicted from the one month accommodation regression model due to changes in management practices.

In summary, the present study confirmed the importance of age as an independent predictor of increased dependency at one month post-fracture. It also showed that physical health, fracture type and dependency, as gauged by 'how the patient managed on a daily basis', total Barthel score and the inside walking aid, were predictive of short term dependency and these important findings have not previously been reported in the literature. Reasonable prediction was obtained for the ordered logistic regression model as indicated by AUC ranging from 0.74 to 0.86. One month dependency may be a more objective measure of early return to the community compared to the actual accommodation status at one month as the latter is very much dependent upon prevailing management practice.

### 5.5.2 Whole Study

As for the self-reporting group of patients the total Barthel score at one month was categorised in the same way that it was for the multivariate analysis. However unlike the SRG of patients there were sufficient numbers to warrant the sub-division of the dependent group into three categories. 20 individuals had Barthel scores of 4 or less indicative of total dependence, whilst 36 had scores of between 5 and 8 suggesting severe dependence. A further 21 people were also dependent, but less profoundly, with scores of 9 to 11 inclusive. The score distribution is given in Figure 5.10. The Barthel score was divided into nine categories for the univariate and multivariate analyses.



**Figure 5.10** One month Barthel Index scores for whole study population

#### 5.5.2.1 Univariate Analysis

Selected univariate results are shown in Appendix 10. They have been classified in the same way as the univariate results for the SRG of patients for one month dependency which are also given in Appendix 10. The univariate results for the whole study population are similar to those obtained for the univariate analyses for the SRG of patients. Age, study status, accommodation, co-residents and main helper, as well as fracture type additionally managed to reach significance with the total Barthel score at one month post-fracture in the whole study population.

### **5.5.2.2 Multivariate Analysis**

An ordered logistic regression analysis was performed.

#### **5.5.2.2.1 Selection of First Line Variables**

Although none of the studies which have looked at dependency in the short term following a hip fracture have included institutionalised patients the pragmatic decision was taken to use them as the basis for selecting the first line variables for the whole study population. The alternative would have been to have used studies with unselected series of patients that had looked at dependency six to twelve months post-fracture but the timing of this was considered to be too remote from dependency levels at one month post-fracture.

The rationale for selecting the first line variables consequently follows that for the self-reporting group as outlined in section 5.5.1.2.1. Information on depression was not available in the informant requiring group so the total GDS score could not be used as a predictor variable for the whole study group. The total GDS score was replaced by the study status of the patient, that is whether they were self-reporting or informant requiring. It was appreciated that the study status of the patient was largely a composite measure of two of the other first line variables, namely accommodation and the cognitive status of the patient, but it was nonetheless viewed to be of sufficient merit in its own right to be included as a possible first line predictor variable.

#### **5.5.2.2.2 First Line Variables in the Regression Model**

Six first line variables entered the ordered logistic regression model at the 10% level of significance and are given in Table 5.10. The variables, in the order in which they entered the model, were : total Barthel score, total AMT score, the main helper, general health, fracture type and study status. Patients who were in the self-reporting group, in better physical and mental health, were less dependent and or who had sustained an intracapsular fracture were significantly less likely to be dependent at one month post-fracture.

**Table 5.10** One month dependency ordered logistic regression analysis for whole study population

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

<b>a) Significant variables</b>			
Variable	Coefficient	Standard error	P
Intercept 1	2.34	0.91	-
Intercept 2	4.85	0.97	-
Intercept 3	5.81	1.00	-
Intercept 4	6.74	1.02	-
Intercept 5	7.51	1.04	-
Intercept 6	8.30	1.06	-
Intercept 7	9.72	1.08	-
Intercept 8	10.83	1.10	-
Total Barthel score	-0.36	0.05	0.0001
Total AMT score	-0.17	0.06	0.0061
Main helper	0.64	0.26	0.013
General health	-0.27	0.11	0.012
Fracture type	0.54	0.24	0.025
Study status	-0.76	0.42	0.067

<b>b) Non-significant variables</b>	
Variable	P
Age	0.52
Sex	0.41
Accommodation	0.96
Total number of categorised medical conditions	0.42
Managed on a daily basis	0.19
Inside walking aid	0.93

**2. Backward stepwise regression**

Same regression model generated as from forward procedure.

**Table 5.10 (continued)** One month dependency ordered logistic regression analysis for whole study population

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-0.92	1.31	-
Intercept 2	1.42	1.36	-
Intercept 3	2.39	1.38	-
Intercept 4	3.37	1.38	-
Intercept 5	4.18	1.39	-
Intercept 6	5.00	1.39	-
Intercept 7	6.51	1.39	-
Intercept 8	7.67	1.40	-
Total Barthel score	-0.23	0.06	0.0002
Total AMT score	-0.17	0.06	0.0051
Main helper	0.43	0.26	0.10
General health	-0.22	0.11	0.034
Fracture type	0.65	0.24	0.065
Study status	-0.68	0.41	0.10
Outside walking aid	0.11	0.05	0.037
Clackmannan self-care subscale score	0.13	0.07	0.042

The forward step-wise model generated was robust as indicated by the same variables being included using a backward step-wise procedure.

**5.5.2.2.3 Final Regression Model**

Adding in the second line predictor variables into the ordered logistic regression model resulted in the inclusion of the outside walking aid prior to the fracture and the Clackmannan self-care subscore. Poorer walking ability and impairment in self-care were predictive of increased dependency. The Barthel mobility and self-care subscores were not included as potential second line predictors as the total Barthel score had already been incorporated into the first line regression model. The model was re-run excluding variables that had missing values and this did not result in any change of the variables that were entered into the model. No further variables entered



the logistic regression model when the third line variables were included. The final regression model is presented in Table 5.10.

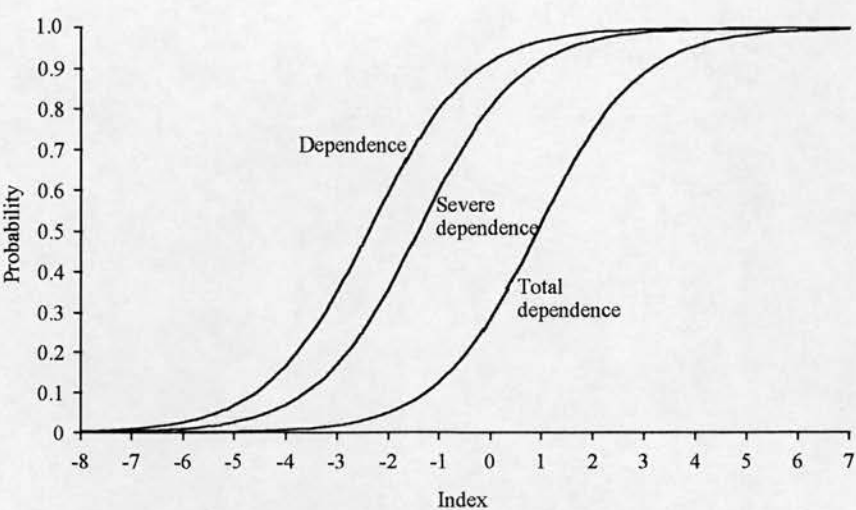
Calculating the antilogarithms of the coefficients for the predictor variables in the ordered logistic regression model for dependency it can be seen that odds ratio of being in a more dependent category at one month post-fracture is greatest for being in the IRG compared to the SRG with the odds ratio being 1.97. A similar odds ratio of 1.92 was obtained for a patient sustaining an extracapsular fracture compared to an intracapsular fracture. A deterioration in status by one point for the general health, total Barthel score, AMT score, main helper, Clackmannan self-care and the outside walking aid variables corresponded to an increased odds ratio of 25%, 25%, 19%, 54%, 14% and 11% respectively of being in a more dependent category. The number of possible levels for these variables were 5, 21, 11, 2, 11 and 9 respectively.

#### **5.5.2.3 Prediction in Practice**

The total Barthel score at one month for the whole study population was subdivided into nine categories. However for ease of presentation the graphical results will be simplified by amalgamating the categories into four groups corresponding to total Barthel scores of less than or equal to four (total dependence), five to eight (severe dependence), nine to 11 (dependence) and 12 to 20 (independence).

As detailed in section 5.5.1.3 a series of sigmoid curves may be obtained from the ordered logistic regression model and be used to facilitate the determination of the probability of each grade of dependency for any given value of the index. Referring to Figure 5.11 it can be seen that a patient with an index value of -2.41 for example would have a probability of being totally dependent of 0.035, of being severely or totally dependent of 0.27 or of some degree of dependency of 0.50. To generate an index value of -2.41 the baseline characteristics of the patient could be as follows : self-reporting, residential care, extracapsular fracture, fair general health, total AMT score of seven, total Barthel score of 14, Clackmannan self-care subscore of four, required one person to help when walking outside. The main helper category was

treated numerically as a binary variable. Patients whose main helper was from the health and social services were coded as 2 and the others were



**Figure 5.11** One month dependency sigmoid curves for the whole study population

coded as 1. The numerical values for the other categorical variables in the index formula are given in Appendix 11.

The index values for dependency at one month derived from the regression model and the actual total Barthel scores at this point in time are given in Table 5.11. Low

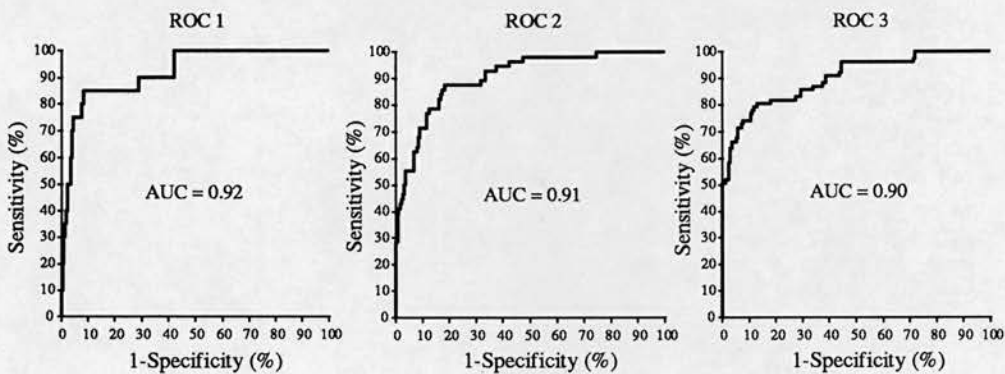
**Table 5.11** Prognostic index value cross-tabulated against observed one month dependency for whole study population

Index	Observed frequency for Barthel score							Total
	0-4	5-8	9-11	12-16	17-18	19	20	
-8.00-<-6.01	0	0	0	0	8	8	6	22
-6.00-<-4.01	0	1	3	10	23	8	10	55
-4.00-<-2.01	2	4	5	13	26	9	4	63
-2.00-<0.01	1	6	2	19	17	0	0	45
0.00-<1.99	0	11	3	4	2	0	0	20
2.00-<3.99	3	6	7	2	2	0	0	20
4.00-<5.99	10	7	2	0	0	0	0	19
6.00-<7.99	4	1	0	0	0	0	0	5

values of the index corresponded to less dependency. A Spearman's correlation coefficient of -0.77 was obtained for the association between the index score and the observed total Barthel score at one month post-fracture. This close association was expected given that the same data set was used to generate each of the variables. The patient with the index value of -2.41 described in the previous paragraph can be seen

to have a probability of 0.041 of being in the totally dependent group, 0.31 of being in the severely or totally dependent group and 0.43 for being in any dependent category from Table 5.11 using the index range -4.00 to less than -2.00.

The ROC curves obtained from the regression model for dependency at one month for the whole study population indicate its good predictive capacity with AUC ranging from 0.90 to 0.93 as shown in Figure 5.12. A sensitivity of 80% corresponded to a specificity of 88% for total dependence versus severe dependency of less as shown in the first ROC curve. The best prediction was obtained for dependence versus independence with a sensitivity of 80% corresponding to a specificity of 90%.



**Figure 5.12** One month dependency serial ROC curves for whole study population

#### 5.5.2.4 Discussion

As mentioned in the selection of first line variables section none of the studies which have investigated the relationships between baseline variables and short term physical functioning following a hip fracture have included institutionalised patients. This makes direct comparison of the results of the current analysis with the literature problematical. A limited discussion will consequently follow.

Age achieved univariate significance with dependency at one month for the whole study population in the current study and confirms the findings by Barnes and Dunovan (1987) and Broos et al (1988). It failed however to attain multivariate significance which contrasts with the results of Marottoli et al (1992). This was noted

to be due to confounding by the total AMT score and the type of main helper. The study status of the patient which reflects cognitive ability and the place of pre-fracture residence reached independent significance in the current analysis reflecting the dependency of the institutionalised patients in the whole study population. Interestingly the total AMT score also entered the model in addition to study status despite overlap of the domains encompassed. Marottoli et al (1992) also reported that cognitive functioning was predictive of dependency. General health reached multivariate significance in the current study but the literature only supports univariate findings (Broos et al 1988, Marottoli et al 1992). The importance of pre-fracture dependency in predicting future dependency was highlighted by the baseline total Barthel score, the Clackmannan self-care subscale, the type of outside walking aid required and the main helper prior to the fracture all attaining multivariate significance. In the literature the only study to report a significant association for this area was the one by Marottoli et al (1992) and even then this study only reported a univariate relationship between baseline physical functioning and function at six weeks post-fracture. The current study also revealed the finding that an extracapsular fracture was independently predictive of increased dependency which has not been previously reported in the literature even at a univariate level (Broos et al 1988, Marottoli et al 1992).

In summary, variables indicative of mental and physical frailty prior to a hip fracture, as well as the fracture type, are predictive of increased dependency at one month post-fracture in an unselected series of patients. Direct comparisons of these results with the literature are not possible as no comparable studies have been reported in the literature. The ROC curves illustrated the good predictive capacity of the regression model with AUC ranging from 0.90 to 0.92.

### **5.5.3 Comparison of Self-reporting Group and Whole Study Population**

The self-reporting group comprises two thirds of the whole study population so it was not surprising to note the similarity between the significant univariate and multivariate results in the two cohorts of patients. A greater number of significant predictor



variables for the whole study population was obtained reflecting the greater homogeneity in this group compared to the SRG and the larger number of patients which increases the power of the study to find significant relationships.

The increased frailty of the informant requiring group was made explicit by the additional statistically significant relationships involving baseline variables which reflected dependency in the whole study cohort. At a univariate level the variables age, category, accommodation, co-residents and main helper, as well as fracture type attained significance in the whole study population whilst not managing to do so with the SRG of patients. At a multivariate level study status, the total AMT score, the Clackmannan self-care subscore and the type of main helper additionally managed to reach significance in the whole study population. The two variables age and how the patient managed on a daily basis which appeared in the ordered logistic regression model for the SRG of patients failed however to do so for the whole study population. It was noted that age was confounded by the total AMT score and the type of main helper in the whole study population analysis whilst 'how the patient managed on a daily basis' was mainly confounded by total Barthel score and general health. From an observational viewpoint it was also noted that the physiological age of the SRG of patients correlated more strongly with their chronological age than was the case for the IRG group where the former exceeded the latter.

The predictive capacity for the regression models obtained for the SRG of patients and for the whole study, as indicated by the serial ROC curves generated from them, was better for the whole study population. This is again largely attributable to the greater heterogeneity in the whole study population which makes prediction easier.

## **5.6 SUMMARY**

The independent predictors for mortality, accommodation, depression and dependency at one month post hip fracture have been identified. Comparison of the results of the current study with the literature are limited, for depression and dependency in particular, due to the paucity of published material in these domains in



relation to hip fracture patients, but this situation should change with the developing interest in medical outcomes. The important predictive role of age and pre-fracture frailty have clearly been identified in this study for one month mortality, accommodation and dependency as well as the psychological variables for predicting future depression.

Mortality at one month post-fracture was predicted only by age, 'how the patient managed on a daily basis' and the type of walking aid used inside prior to the fracture.

The small number of predictor variables identified were due to the few deaths which had occurred, making it difficult to obtain good prediction over this short period of time. This study is the first one to report the predictive role of walking aid dependence on subsequent mortality. It was surprising that general health failed to attain independent significance.

Baseline predictors of accommodation at one month post-fracture for the self-reporting group of patients were age, co-residents, mental state, how the patient managed on a daily basis, the Clackmannan self-care subscale, and fracture type. An unexpected finding in these patients with a high level of cognitive functioning was that cognitive function was nonetheless still predictive of return to the community. It was wrongly anticipated that general health would have an independent predictive role. The baseline predictor variables for one month accommodation were important to identify because of their potential role in assisting patients to be selected for early supported discharge to the community. These baseline predictors in part however reflect current management practices and an alternative objective measure of suitability for early return to the community is dependency as gauged by the Barthel Index. Six predictor variables were obtained for both accommodation and dependency at one month post-fracture for the SRG of patients. Age, 'how the patient managed on a daily basis' and fracture type were variables common to both outcome variables. Mental and social factors as well as self-care were important for prediction of accommodation whilst variables reflecting general physical health and frailty were more important for the prediction of dependency at one month. This

suggests that the mental state of the patient and social factors influence management decisions on discharge.

The predictors identified for dependency for the whole study population at one month were a subset of variables which were largely indicative of pre-fracture dependency namely 'how the patient managed on a daily basis', the total Barthel score, and the outside walking aid required. Additionally age, general health and fracture type also entered the model. There was considerable overlap between the predictor variables obtained for dependency for the SRG of patients and the whole study population. This was not surprising because the former group comprises two thirds of the latter. Additional significant predictors were obtained for the whole study population compared to the SRG of patients reflecting their greater homogeneity and the larger number of patients which increases the power of the study to detect significant relationships. The additional variables achieving independent significance made explicit the greater frailty of the IRG of patients. These variables were study status, cognitive state, main helper and Clackmannan self-care subscore.

It was unexpected that baseline depression and morale were not predictive of mortality, accommodation or dependency at one month post-fracture. Psychological variables were however understandably found to be predictive of depression as measured as a continuous variable on the Geriatric Depression Scale but were not very useful when the GDS score was simply dichotomised into 'depressed' and 'not depressed'. The psychological variables identified for the former analysis were total GDS score, total PGCMS score, optimism about future walking, whether anyone relied on the patient for help, and the frequency of attendance at church. General health and the outside walking aid also attained significance. When depression was analysed as a binary variable only the total baseline GDS score, whether anyone relied on the patient for help and general health reached significance. The analysis performed for one month depression with the total GDS score as a continuous variable had greater power than when it was analysed as a binary variable. This suggests that numerical values for the GDS are informative, and a dichotomy into

'depressed' and 'non-depressed' may be too simple. The usefulness of the short form of the GDS in classifying depression still has to be verified.

A comparison of the AUC for the ROC curves generated from the regression models for the various outcome variables indicated that the poorest prediction was obtained for mortality and the best for dependency for the whole study population. Mortality was considerably separated from the other outcome variables in terms of its predictive capacity and may be attributed to the small number of deaths which had occurred at one month post-fracture. In clinical practice the regression model for mortality would not be of great benefit as no patient had a predicted probability of dying of greater than 50%. On the other hand good prediction was obtained for the other outcome variables. The best predictive model was obtained for dependency at one month for the whole study population with the AUC ranging from 0.90 to 0.93. A sensitivity of 80% was associated with a specificity of 90% for predicting dependency versus independence. In other words there was an 80% chance of correctly predicting dependency and a 90% chance of correctly predicting independence with the model.

## **CHAPTER 6**

### **PREDICTION OF TWELVE MONTH OUTCOME**

#### **6.1 INTRODUCTION**

The purpose of this chapter is to present the baseline predictors for the six selected 12 month outcome variables which are mortality, accommodation, depression, dependency, hip function and hip pain. Refer to section 3.5.2 for further detail on the selection of the outcome variables. The chapter format will follow that used for the preceding chapter on the one month outcome variables. Additionally a comparison of the use of different multivariate techniques will be presented for dependency to give an indication of the importance of the statistical approach used to determine the predictor variables.

#### **6.2 TWELVE MONTH MORTALITY**

At one year post-fracture 77 deaths had occurred representing 29% of the study population. No exclusions were made for the analysis.

##### **6.2.1 Univariate Analysis**

The important univariate analysis results are presented in Appendix 12. Most of the baseline demographic, physical and mental health parameters were significantly associated with survival as was fracture type. Sex and marital status however failed to attain significance. The majority of the mobility variables, the physical and social dependency measures, and fracture type were very highly significantly associated with mortality.

##### **6.2.2 Multivariate Analysis**

###### **6.2.2.1 Selection of First Line Variables**

The basic demographic variables age and sex were included because of their fundamental importance in epidemiological research. Age has been incorporated into every study looking at the mortality of patients with a hip fracture. Gender has also been extensively investigated (Miller 1978, Kenzora et al 1983, Jensen 1984, White et al 1987, Elmerson et al 1988, Dolk 1989, Magaziner et al 1989, Sernbo and Johnell 1993, Marottoli et al 1994). Accommodation was included in the present



study because earlier work had suggested it would be predictive of mortality (Evans et al 1979, Dolk 1989). The presence of impaired cognition has been recognised as being predictive of death following a hip fracture thereby justifying its inclusion as a first line variable for logistic regression (Baker et al 1978, Miller 1978, Evans et al 1979, Ions and Stevens 1987, White et al 1987, Magaziner et al 1989, Mossey et al 1989, Mullen and Mullen 1992, Marottoli et al 1994). The study status was added to the list of first line predictor variables as this classification was based on information on the place of residence at baseline and/or the patient's mental state in the majority of cases and may have proved to be a useful composite predictor. Several studies have emphasised the importance of the patient's general health. Dahl (1980), Kenzora et al (1983), Davidson (1986), Magaziner et al (1989), Mossey et al (1989), and Marottoli et al (1994) have all looked at the effect of comorbidity on mortality. This has been well documented in other studies looking at medical admissions to acute hospitals (Charlson et al 1988, Cohen et al 1992). Marottoli et al (1994) included physical functioning in their study looking at the predictive factors for mortality at six months post-fracture. The total Barthel score was included as a measure of dependence due to its widespread use in rehabilitative medicine. A further ad hoc question on 'how the patient managed on a daily basis' was added to provide further information on dependence which intuitively was thought to be important in predicting mortality. Fracture type has also been extensively investigated in relation to mortality in the longer term following a hip fracture with the majority of the studies finding a positive association between extracapsular fracture and mortality (Gordon et al 1971, Evans et al 1979, Kenzora et al 1983, White et al 1987, Magaziner et al 1989, Dolk 1989, Keene et al 1993, Marottoli et al 1994). As a consequence fracture type was added to the list of potential first line predictors in the current study.

#### **6.2.2.2 First Line Variables in the Regression Model**

Using the forward stepwise regression procedure five baseline variables entered the model at the 10% level of significance. In order of entry these variables were total Barthel score, age, general health, fracture type and total number of categorised



medical conditions. The significance of these independent predictors are given in Table 6.1.

**Table 6.1** Twelve month mortality logistic regression analysis

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

**a) Significant variables with total Barthel score in the model**

Variable	Coefficient	Standard error	P
Intercept	5.26	1.96	-
Total Barthel score	0.068	0.036	0.058
Age	-0.059	0.020	0.0031
General health	0.29	0.13	0.025
Fracture type	-0.58	0.30	0.048
Total number of categorised medical conditions	-0.24	0.13	0.068

**b) Significant variables with total Barthel score not in the model**

Variable	Coefficient	Standard error	P
Intercept	6.62	1.73	-
General health	0.33	0.13	0.0092
Age	-0.06	0.02	0.0013
Total number of categorised medical conditions	-0.30	0.12	0.0088
Fracture type	-0.57	0.29	0.03

**c) Non-significant variables**

Variable	P
Sex	0.48
Accommodation	0.12
Study status	0.79
Total AMT score	0.32
Total number of categorised medical conditions	0.65
Number of medications	0.13
Managed on a daily basis	0.21

**2. Backward stepwise regression**

The same regression model was generated as with the forward stepwise regression procedure.

**Table 6.1 (continued)** Twelve month mortality logistic regression analysis

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	5.60	1.81	-
General health	0.23	0.13	0.086
Age	-0.057	0.020	0.0049
Total number of categorised medical conditions	-0.22	0.13	0.078
Fracture type	-0.65	0.30	0.031
Maximum supported walking distance	0.33	0.11	0.0022

However when the second line variables were entered into the model the variable the maximum supported walking distance was noted to confound strongly the total Barthel score with its probability rising to 0.81. As a result of this the first line regression analysis was re-performed with the total Barthel score not included. No additional first line variables entered the model as shown in Table 6.1 part A.1.(b). The non-significant variables for this analysis are given in part A.1.(c) of Table 6.1.

The robustness of the forward step-wise regression model was verified when the same regression model was obtained when a backward step-wise procedure was performed.

**6.2.2.3 Final Regression Model**

Adding in the second and third line variables to the regression model resulted in the maximum supported walking distance being included into the final model at the 5% level of significance.

The odds ratio for survival for each of the predictor variables can be calculated from the logistic regression model by taking the antilogarithm of its coefficient as outlined in section 5.2.2.3. Fracture type had the greatest impact on survival. Sustaining an extracapsular fracture was associated with an odds ratio of 0.52 of surviving to one year post-fracture relative to a patient who had sustained an intracapsular fracture. The odds ratio of survival for every decade increase in age was 0.57. Each additional

categorised medical condition, up to a maximum of 10, was associated with an odds ratio for survival of 0.80. An increment in general health on its five point scale, with a higher score indicating better health, was associated with an increased odds ratio of survival of 1.25. Each improvement in the maximum supported walking distance on its five point scale was associated with a 1.39 times improved odds ratio of survival. Refer to Appendix 11 for the composition of the categorical predictor variables.

### 6.2.3 Prediction in Practice

The logistic regression model derived for 12 month survival was:

$$y = 5.60 - (0.057 \times \text{age}) - (0.65 \times \text{fracture type}) + (0.23 \times \text{general health}) - (0.22 \times \text{number of categorised medical conditions}) + (0.33 \times \text{supported maximum walking distance})$$

The categorical variables used in this formula take the numerical values shown in Appendix 11. For each patient in the study a value of  $y$  was calculated. The probability of death for every study participant in the first year can therefore be calculated as in section 5.2.3 :

$$p = 1 / (1 + e^y)$$

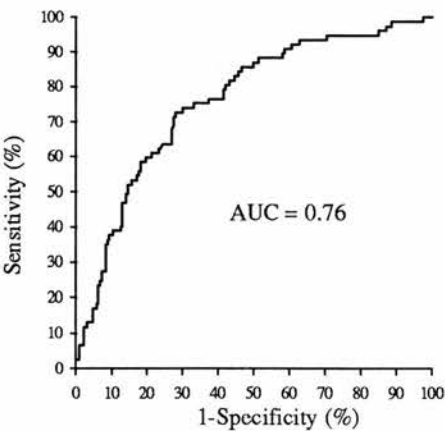
To illustrate the use of the regression model in predicting the mortality for a specific patient at one year post-fracture an example will be given. A 72 year old woman who was in fair general health, who suffered from angina, arthritis and urinary incontinence, which corresponded to three categorised medical conditions as outlined in section 3.5.1, could walk only 50 to 100 yards outside prior to her extracapsular fracture can be calculated to have a  $y$  value of 0.031. This corresponds to a probability of 0.49.

Table 6.2 shows the probability of death as derived from the logistic regression equation just presented and the actual survival status in the study population at 12 months. It should be

**Table 6.2** Predicted versus observed 12 month mortality

Predicted probability	Observed frequency			Observed probability
	Dead	Alive	Total	
0.00-0.09	4	41	45	0.09
0.10-0.19	8	63	71	0.11
0.20-0.29	8	30	38	0.21
0.30-0.39	13	23	36	0.36
0.40-0.49	18	19	37	0.49
0.50-0.59	15	8	23	0.65
0.60-0.69	8	7	15	0.53
0.70-0.79	3	2	5	0.60

noted that validation of the model is required on an independent data set as using it on the study population from which it was derived means that the predicted event and the actual outcome will be related. Despite this limitation the results are included to demonstrate the goodness of fit obtained by the model. Referring to Table 6.3 it can be seen for example, that a probability of dying of less than 0.10 as predicted from the logistic regression equation corresponded to an actual mortality of 9% in the study population. For a 0.40 to 0.50 predicted probability of dying 49% of study participants in this stratum actually died.



**Figure 6.1** 12 month mortality ROC curve

The usefulness of the regression model for prediction is summarised graphically in Figure 6.1. Receiver operator curves are explained in section 5.2.3. The AUC for 12 month mortality is 0.76 indicating reasonable prediction. It can also be seen from the figure that an 80% chance of correctly predicting death is associated with a 58% chance of correctly predicting survival.

#### 6.2.4 Discussion

The observed relationship between age and mortality was anticipated and is consistent with the literature. Mortality has been reported as ranging from 14% to 43% at one year post-fracture for comparable studies using unselected series of older patients (D'Arcy and Devas 1976, Miller 1978, Jensen and Tondevold 1979, Kenzora et al 1983, Jensen 1984, Holmberg and Thorngren 1987, Davidson and Bodley 1986, White et al 1987, Elmerston et al 1988, Dolk 1989, van der Sluijs and Walenkamp 1991, Mullen and Mullen 1992, Keene et al 1993, Sernbo and Johnell 1993). The relationship was confirmed multivariately by Miller (1978), Jensen (1984), Elmerston et al (1988), Dolk (1989), Kuokkanen and Korkala (1992), and by Sernbo and Johnell (1993). Ions and Stevens (1987) also noted this multivariate relationship in their series of intracapsular patients. The importance of age in predicting mortality was emphasised by the fact that in the final model in the current study it was the most significant term.

Despite the fact that women were significantly older than men by four years, their overall mortality approximated that of the men in the present study. As noted for early hip fracture mortality, this result was not surprising given the higher age-specific mortality in men (Register General for Scotland 1993). Kenzora et al (1983) and Jensen (1984) supported this finding. However, the studies by Miller (1978), Elmerston et al (1988), Dolk (1989), Magaziner et al (1989) and Sernbo and Johnell (1993) all indicated that male sex was associated with a significantly higher risk of death both at a univariate and multivariate level.

More dependent forms of baseline accommodation were found to be predictive of mortality at 12 months on univariate analysis in the present study and similar findings for late mortality have been reported elsewhere (Evans et al 1979, Jensen 1984, Ions and Stevens 1987, Elmerston et al 1988, Narain et al 1988, Dolk 1989). The relationship held at a multivariate level in the studies by Evans et al (1979) and Elmerston et al (1988), Dolk (1989) and Kuokkanen and Korkala (1992). In the current study it was noted that the sub-group of patients who were in more dependent



forms of care were older and frailer which confounded the independent effect of accommodation.

Although the informant requiring group had a significantly higher mortality than the SRG of patients on univariate analysis, it was not found to be an independent predictor on multivariate analysis. Confounding factors included a higher average age, poorer general health, and more extracapsular fractures in the IRG of patients. Moreover, given that this variable is basically a composite measure of the mental status of the patient and their baseline accommodation it was consistent with the result that neither of these constituent variables were significant predictors on logistic regression.

An excess of mortality in people sustaining an extracapsular fracture in the current study which attained significance at the univariate level and this is in accordance with the results from the studies by Dolk (1989) and Keene et al (1993). Evans et al (1979), Jensen(1984), White et al (1987), Magaziner et al 1989, and Mossey et al (1989) failed to demonstrate this. At a multivariate level the significant association was preserved in the current study and supported the work by Dolk (1989) and Marottoli et al (1994).

Co-morbidity has been reported in the literature as being predictive of death following a hip fracture at the univariate level (Evans et al 1979, Dahl 1980, White et al 1987). At a multivariate level the importance of general health and comorbidity in predicting future survival has been reported by Magaziner et al (1989), Mossey et al (1989) and Marottoli et al (1994) but not by Evans et al (1979) and Dolk (1989). In the current study general health and the total number of categorised conditions both achieved independent significance multivariately. The number of medical conditions and number of medications were confounded by the previous two variables and failed to achieve independent significance.

The fact that the mental state of the patient failed to achieve independent significance in the regression model, as mentioned earlier, was the main unexpected finding in the multivariate analysis for the prediction of 12 month survival. This was a result of its strong associations with age and fracture type in particular. This result agrees with the study performed by Magaziner et al (1989). Magaziner et al however used a community residing population whose mental state could be expected to be reasonably good and consequently less useful as a discriminatory variable for predictive purposes. The literature suggests that mortality is significantly associated with impaired cognitive functioning at the multivariate level (Miller 1978, Evans et al 1979, Ions and Stevens 1987, Mossey et al 1989, Kuokkanen and Korkala 1992, Marottoli et al 1994). Using a cohort of elderly medical patients admitted to an acute hospital Narain et al (1988) supported this association although other studies have not (Cohen et al 1992, Incalzi et al 1992).

The only mobility parameter to be included in the final regression model was the supported maximum walking distance even though they all showed very highly significant relationships univariately. Review of the regression model revealed that this was largely due to the strong association of the other mobility parameters with the supported maximum walking distance. Walking distance has not been previously reported in the literature as being a predictive factor for survival at 12 months post hip fracture. The only study to report on walking ability per se was the one by Dolk (1989) and he reported that poorer walking capacity in terms of aid requirement was predictive of death using multiple discriminant analysis.

Jensen(1984) reported that dependency, rated on a four point scale, ranging from complete independence where the patient could manage everything, up to total dependence requiring institutional care, was multivariately related to death in his cohort of 518 patients whom he followed up for an average of three years. Sernbo and Johnell (1993) reported that the ability of the patient to do their own shopping prior to their fracture was predictive of one year mortality. In the current study the total Barthel score attained independent significance but was later removed from the

regression model due to it being confounded by the maximum supported walking distance, which showed a stronger association with mortality. Marottoli et al (1994) did not find that functional ability was significantly related to mortality at six months post-fracture at either the univariate or multivariate levels of analysis.

Studies of the elderly have indicated that social factors are protective against mortality using both univariate and multivariate statistical techniques (Berkman and Syme 1979, Blazer 1982, Seeman et al 1987, House et al 1988, Hanson et al 1989, Sugisawa 1994). However, in this study, apart from the social factors which directly reflected dependency, for example the patient's main helper, the other social factors, such as the frequency of visitors, did not have a significant bearing on mortality at either a univariate or multivariate level. This may reflect in part the difficulty in assessing social factors in quantitative terms. The social activity variables in the study by Marottoli et al (1994) also failed to reach univariate significance with mortality.

In summary, the current study confirmed the importance of age in predicting mortality. It also highlighted the importance of fracture type with extracapsular fractures being associated with a higher mortality although the majority of studies failed to demonstrate this. The present study also found physical health to be predictive of mortality which has been reported inconsistently in the literature. Mental health in the present study was not found to be independently predictive of survival which contrasts with the majority of the literature and the reason for this is not clear. In the EHFS mental health was noted to be strongly confounded by age and fracture type. Few studies have reported directly on the role of pre-fracture mobility on subsequent mortality. In the present study the maximum supported walking distance was determined to be predictive of death and this is a new finding. Social factors were not found to be independent predictors of survival in the current study although the literature about general geriatric populations indicates that they are important.

## **6.3 TWELVE MONTH ACCOMMODATION FOR SELF-REPORTING GROUP**

Two analyses were performed for accommodation at 12 months post-fracture. The first analysis looked at the predictors of actual place of residence at one year post-fracture and the second addressed whether the patient had moved into a more dependent form of accommodation or not. The rationale for the second analysis was so that any change in accommodation could be predicted.

The 77 patients who died and the four patients who developed a significant acute medical condition during the year of follow-up which interfered with the assessment of the impact of their hip fracture were excluded from the analyses.

### **6.3.1 Univariate Analysis**

The important univariate analyses for the baseline variables and 12 month accommodation are presented in Appendix 12. Accommodation at 12 months was treated as an ordered categorical variable with 6 levels for the analysis. However to be in keeping with the classification used for the ordered logistic regression analysis it is presented in Appendix 12 as three amalgamated categories. The three categories are : accommodation in a private residence, supported care in the community and institutional care.

Of the demographic variables, age, co-residents and baseline accommodation attained univariate statistically significant associations with accommodation at twelve months.

The only general health variable to do this was the 'number of hospitalisations in the year preceding the hip fracture'. Strong univariate relationships were obtained with the mental health variables, activities of daily living and the mobility parameters. The type of main helper also attained significance. None of the other social variables achieved significance at the univariate level.



### **6.3.2 Multivariate Analysis**

As mentioned briefly in the introduction to this section the multivariate analysis for 12 month accommodation was performed in two different ways. Firstly, the 12 month accommodation was categorised into three groups : 'own home or home of a relative or friend', 'sheltered or residential care', or 'nursing home or long stay care'. An ordered logistic regression procedure was then used. The second analysis was based on whether the patient had moved into a more dependent form of accommodation one year after the fracture. The outcome variable was treated as a simple binary variable 'more dependent' and 'not more dependent' and logistic regression was used. The basis for performing the first analysis was so that the actual place of residence at 12 months could be predicted whilst for the second it was so that any change in accommodation that occurred during the year after the hip fracture could be predicted and this may be important for planning purposes.

#### **6.3.2.1 Selection of First Line Variables**

Age has been incorporated as a possible predictor of accommodation in most studies looking at placement of hip fracture patients six to twelve months post-fracture thereby justifying its inclusion in the present study (Ceder et al 1980, Furstenberg and Mezey 1988, Bonar et al 1990, van der Sluijs and Walenkamp 1991, Sernbo and Johnell 1993, Marottoli et al 1994). Gender has also been investigated as a possible predictive factor for placement and has not been found to be predictive of future accommodation at a multivariate level (Ceder et al 1980, Furstenberg and Mezey 1988, Bonar et al 1990, Marottoli et al 1994). It was nonetheless included in the current study because of its basic epidemiological importance. Pre-fracture accommodation has also not surprisingly been used as a potential predictor of subsequent accommodation (Ceder et al 1980, Furstenberg and Mezey 1988, van der Sluijs and Walenkamp 1991, Sernbo and Johnell 1993). The importance of living with someone as being predictive of returning to the community has been well documented in the literature (Ceder et al 1980, Furstenberg and Mezey 1988, Bonar et al 1990, van der Sluijs and Walenkamp 1991, Sernbo and Johnell 1993). The role of general health in predicting future placement has also been investigated although only one



study has managed to achieve a significant association at a univariate level (Ceder et al 1980, Furstenberg and Mezey 1988, van der Sluijs and Walenkamp 1991, Marottoli et al 1994). Despite this because of its intuitive importance it was incorporated as a potential predictor in the current study. The variables 'self-rated general health' and the 'number of categorised medical conditions were used for this purpose. Mental state has been looked at by Ferstenberg and Mezey (1988), Bonar et al (1990) and van der Sluijs and Walenkamp (1991), Sernbo and Johnell (1993) and Marottoli et al (1994) and all found that impaired cognition negated against returning to the community. The total AMT score and the Geriatric Depression Scale score were included in the current study to assess the predictive status of cognitive functioning. Dependency has been widely investigated as a potential predictor of placement with increasing dependency decreasing the probability of being in the community one year post-fracture (Ceder et al 1980, Bonar et al 1990, van der Sluijs and Walenkamp 1991, Sernbo and Johnell 1993, Marottoli et al 1994). The parameters 'how the patient managed on a daily basis', the total Barthel Index, and the main helper were incorporated into the group of potential first line predictors for the current study to cover dependency. Most of the studies reported in the literature have assessed walking ability two to three weeks post-fracture in relation to place of domicile at one year post-fracture (Ceder et al 1980, Furstenberg and Mezey 1988, van der Sluijs and Walenkamp 1991). Sernbo and Johnell (1993) used pre-fracture walking ability in their analysis. The ability to visit someone prior to the fracture has also been reported in the literature as being predictive of community residence one year post-fracture (Ceder et al 1980, van der Sluijs and Walenkamp 1991, Sernbo and Johnell 1993).

#### **6.3.2.2 Ordered Logistic Regression**

In this analysis 12 month accommodation was categorised into three groups reflecting private residence, supported community care, and institutional care. In this analysis the actual accommodation was being assessed at baseline and one year post-fracture and not whether any change had occurred in place of domicile.

**6.3.2.2.1      First Line Variables in the Regression Model**

Six first line variables entered the regression model when a forward stepwise procedure was used. In descending order of entry these variables were : accommodation, 'how the patient managed on a daily basis', total GDS score, total AMT score, total Barthel score and age. Patients who were from less dependent forms of accommodation prior to their fracture, had better cognition, were less depressed, and who were more independent were more likely to be in less dependent forms of accommodation at one year post-fracture. This information is summarised in Table 6.3. The first line variables which did not attain independent significance at the 10% level are also given in Table 6.3.

The same regression model was obtained using a backward stepwise procedure indicating that the model was robust.

**Table 6.3** Twelve month accommodation ordered logistic regression analysis

<b>A.      FIRST LINE PREDICTOR VARIABLES</b>			
<b>1.      Forward stepwise regression</b>			
<b>a)      Significant variables</b>			
Variable	Coefficient	Standard error	P
Intercept 1	-1.68	4.03	-
Intercept 2	0.36	4.03	-
Accommodation	-0.65	0.23	0.0040
Managed on a daily basis	-0.62	0.33	0.058
Total GDS score	-0.15	0.078	0.051
Total AMT score	0.48	0.23	0.037
Total Barthel score	0.25	0.12	0.044
Age	-0.053	0.031	0.087

**Table 6.3 (continued)** Twelve month accommodation ordered logistic regression analysis

b) Non-significant variables	
Variable	P
Sex	0.42
General health	0.44
Total number of categorised medical conditions	0.81
Inside walking aid	0.20
Co-residents	0.88
Main helper	0.73
Frequency of visiting others	0.85
Fracture type	0.22

2. Backward stepwise regression

Same model generated as with the forward stepwise procedure.

B. FINAL MODEL

Variable	Coefficient	Standard error	P
Intercept 1	-1.68	4.03	0.68
Intercept 2	0.36	4.03	0.93
Accommodation	-0.65	0.23	0.0040
Managed on a daily basis	-0.62	0.33	0.06
Total GDS score	-0.15	0.078	0.051
Total AMT score	0.48	0.23	0.037
Total Barthel score	0.25	0.12	0.044
Age	-0.053	0.031	0.087

### 6.3.2.2.2 Final Regression Model

None of the second line or third line variables attained independent significance at the 5% and 1% levels respectively. Variables with missing values did not influence the final regression model obtained. The final model was consequently the same as that obtained when only the first line variables had been entered.

Calculating the odds ratio for each predictor variable from their coefficients in the regression model it was determined that an increment in the eleven point AMT score indicating better cognitive functioning, was associated with the greatest odds ratio of

being in a less dependent form of accommodation at twelve months post-fracture with the value being 1.62. The corresponding odds ratio for an advancement on the total Barthel Index, which ranges from 0 to 20 with a higher score indicating more independence, was associated with an odds of 1.28. An increment in the GDS scale, which ranges from 0 to 15 with a lower score indicating less depressive symptomatology, was associated with an odds of 0.81 of being in less dependent forms of accommodation. The corresponding figure for 'how the patient managed on a daily basis', which is a four point scale with a higher score indicating greater dependence, was 0.53. A one step rise in the four types of baseline accommodation with a higher score indicating more dependence, was associated with an odds ratio of 0.52 of being in the less dependent forms of accommodation at 12 months post-fracture. Every decade increase in age was associated with an odds ratio of 0.59 of being in a less dependent form of accommodation.

### **6.3.2.3 Logistic Regression Analysis**

In the second analysis 12 month accommodation was simply dichotomised into 'more dependent' and 'not more dependent' than the baseline place of accommodation. It was performed to assess the predictors of change in accommodation over the year following the hip fracture. Twenty nine of the self-reporting patients were in more dependent accommodation at one year post-fracture whilst 97 were not.

#### **6.3.2.3.1 First Line Variables in the Regression Model**

Five first line variables entered the regression model at the 10% level of significance. These variables, in the order in which they entered the model, were : total GDS score, age, total Barthel score, accommodation and total AMT score. Younger patients, those who were in more dependent forms of accommodation at baseline, had better cognition and less depressive symptomatology and were more independent were significantly less likely to move into more dependent forms of accommodation during the twelve months following a hip fracture. The significant and non-significant variables are summarised in Table 6.4.

The same regression model was obtained using a backward stepwise procedure indicating that the model was robust.

**Table 6.4** Change in 12 month accommodation logistic regression analysis

A. FIRST LINE PREDICTOR VARIABLES

1. Forward stepwise regression

a) Significant variables

Variable	Coefficient	Standard error	P
Intercept	-0.93	4.22	-
Total GDS score	-0.21	0.085	0.013
Age	-0.093	0.036	0.0091
Total Barthel score	0.32	0.13	0.013
Accommodation	0.68	0.35	0.053
Total AMT score	0.42	0.26	0.10

b) Non-significant variables

Variable	P
Sex	0.68
Co-residents	0.21
General health	0.68
Total number of categorised medical conditions	0.41
Managed on a daily basis	0.16
Inside walking aid	0.15
Frequency of visiting of others	0.99
Main helper	0.62
Fracture type	0.43

2. Backward stepwise regression

Same model generated as with the forward stepwise procedure.

B. FINAL MODEL

Variable	Coefficient	Standard error	P
Intercept	-0.93	4.22	-
Total GDS score	-0.21	0.085	0.013
Age	-0.093	0.036	0.0091
Total Barthel score	0.32	0.13	0.013
Accommodation	0.68	0.35	0.053
Total AMT score	0.42	0.26	0.10



#### **6.3.2.3.2      Final Regression Model**

No further variables entered the regression model when the second and third line variables were added. The final model is given in Table 6.4.

#### **6.3.2.4              Comparison of Regression Models**

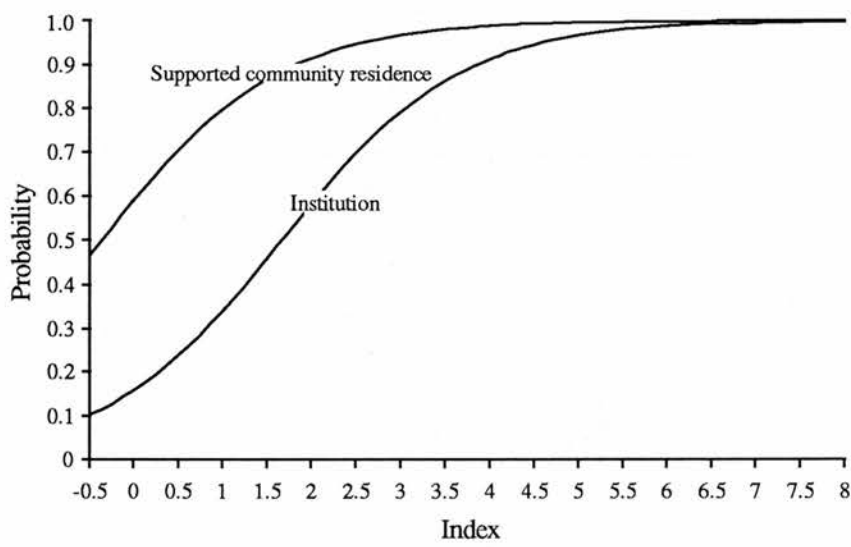
The baseline predictors obtained from the ordered logistic regression and the logistic regression analysis were very similar as may have been anticipated. Age, accommodation, total AMT score, total GDS score, and the total Barthel score were common to both analyses. 'How the patient managed on a daily basis' additionally entered the ordered logistic regression. It was not surprising that more terms entered the ordered logistic regression model because it was using more information than the logistic regression model conferring upon it a greater power to detect significant associations. It was interesting to note that the coefficients for baseline accommodation were different in the two models. For the ordered logistic regression model this indicated that if the patient started off in less dependent forms of accommodation they were more likely to be in the less dependent forms of accommodation one year post-fracture compared to a patient who was in a more dependent form of accommodation at baseline. The actual form of accommodation is being assessed in this model. In the logistic regression model what is being investigated is the change in accommodation status of the patient. If the patient started in less dependent forms of accommodation they were more likely to move into more dependent forms of accommodation over the year following a hip fracture compared to a patient who was already in a more dependent form of accommodation.

It should be noted that no patient in the SRG was by definition resident in institutional care at the time of their fracture. The baseline accommodation for patients in the SRG was classified into own home, home of a relative or friend, sheltered housing and residential care as shown in form II.d in Appendix 5. The accommodation at 12 months post-fracture was simply classified as being unsupported community, supported community and institutional. The unsupported community accommodation covered people in their own homes or that of a relative or friend. Sheltered housing and residential care were classified as being supported

community accommodation whilst nursing homes and long stay care hospitals were classed as being institutions.

### 6.3.3 Prediction in Practice

Figure 6.2 summarises the probability of being in a given type of accommodation or a more dependent one for the full range of index values obtained from the ordered logistic regression model. Further detail about this type of summary presentation for



**Figure 6.2** 12 month accommodation sigmoid curves

an ordered categorical variable is given in section 5.5.1.3. It can be seen approximately from Figure 6.2 that a patient with an index value of 0.81 at the time of their fracture has a probability of 0.28 of being in their own home or that of a relative or friend and a 0.75 probability of being in any type of non-institutional accommodation, which by subtraction yields a probability of 0.47 of being in a supported form of community care. Baseline characteristics of a patient to generate an index value of 0.81 could be : 80 years of age; living in his/her own home; an AMT score of eight; a GDS score of six; managed with great difficulty prior to his/her fracture; and a total Barthel score of 16. The numerical values for the categorical variables are given in Appendix 11.

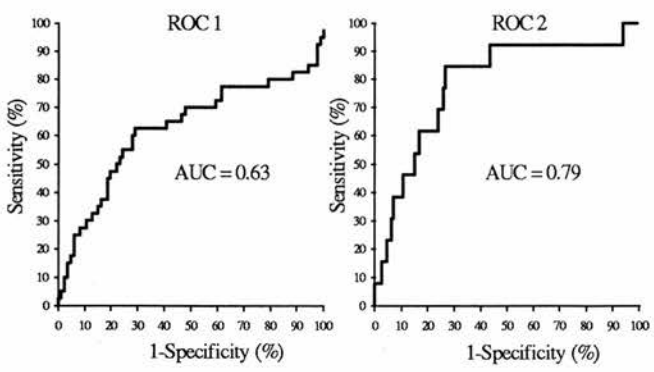
**Table 6.5** Prognostic index values cross-tabulated against 12 month accommodation

Index	Observed frequency			
	Home	Supported community	Institution	Total
-4.00-<-3.01	0	0	0	0
-3.00-<-2.01	0	0	0	0
-2.00-<-1.01	2	2	2	6
-1.00-<0.01	3	4	2	9
0.00- 0.99	16	5	6	27
1.00- 1.99	32	8	2	42
3.00- 3.99	19	2	1	22
4.00- 4.99	12	6	0	18
5.00- 5.99	2	0	0	2

The values for the regression model index are cross tabulated against the actual place of residence at 12 months post-fracture in Table 6.5 to show how close the predicted

and observed accommodation categories were. Patients with an index value in the 0 to 1 range were observed to have a probability of 0.33 of being in their own home or that of a relative or friend, 0.44 of being in supported community care and 0.22 of being in institutional care. These probabilities are comparable to those predicted from the sigmoid curves in Figure 6.2 as discussed in the previous paragraph. A Spearman's rank correlation coefficient of -0.24 was obtained for the index values and the observed place of accommodation at 12 months post-fracture which indicates a weak association only.

The predictive capacity of the regression model for 12 month accommodation as shown in Figure 6.3 is not very high. The first ROC curve illustrates the diagnostic capability for home residence versus supported community care and



**Figure 6.3** 12 month accommodation serial ROC curves

institutional care. The curve has an AUC of only 0.63 with an 80% sensitivity corresponding to a specificity of only 21%. In other words, there is an 80% chance of correctly predicting residence in a private residence and a 21% chance of correctly predicting residence in supported community care or institutional care. The

prediction for community residence versus institutional care is better as indicated by an AUC of 0.79 with an 80% sensitivity being associated with a 74% specificity.

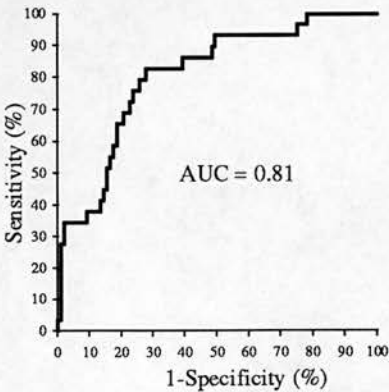
Accommodation at 12 months was also analysed as a binary variable to determine the predictors for a change in accommodation and the regression model is given in Table 6.4. A patient who was 80 years of age, lived in his/her own home, had an AMT score of eight and a total Barthel score of 16 can be calculated to have a y value of 1.72. The probability of remaining in the community can be calculated to be 0.85.

**Table 6.6** Predicted versus observed change in 12 month accommodation

Predicted probability	Observed frequency			Observed probability
	More dependent	No change	Total	
0.00-0.09	2	40	42	0.05
0.10-0.19	3	30	33	0.09
0.20-0.29	6	9	15	0.40
0.30-0.39	7	5	12	0.58
0.40-0.49	1	8	9	0.11
0.50-0.59	2	4	6	0.33
0.60-0.69	3	0	3	1.00
0.70-0.79	3	0	3	1.00
0.80-0.89	2	1	3	0.67
0.90-1.00	0	0	0	n/a

that there were only small numbers of patients with probabilities above 0.50. This means that the selection of the boundaries for the predicted probability categories can have a marked effect on the apparent goodness of fit of the model. Amalgamating the probability categories into the four groups 0.00-<0.10, 0.10-<0.30, 0.30-<0.60 and 0.60-1.00 enhances the apparent usefulness of the model. These groupings correspond to an observed chance of being in a more dependent form of accommodation of 0.048, 0.19, 0.37 and 0.89 respectively. A reasonable AUC was obtained for the ROC curve for change in accommodation as shown in. Figure 6.4. The AUC was 0.81 and a

Table 6.6 shows the predicted probability of a change in accommodation compared to what was actually observed. For example, it can be seen that a predicted probability of 0.10 to 0.20 corresponds to an observed chance of 0.091. It should be noted



**Figure 6.4** Change in 12 month accommodation ROC curve

sensitivity of 80% was associated with a specificity of 72%. In other words with a cut-off value for the index giving an 80% chance of correctly predicting a change in accommodation to a more dependent form, there was a 72% chance of correctly predicting no change in accommodation category.

#### **6.3.4 Discussion**

The importance of a lower age in predicting the same place of domicile one year after the hip fracture is well documented in the literature. Ceder et al (1980) and Bonar et al (1990) found age was an independent predictor in their community-based patients as did the current study when changes in accommodation were analysed. Sernbo and Johnell (1993) also reported this for their unselected series of patients which included cognitively impaired subjects. The studies by van der Sluijs and Walenkamp (1991), Furstenberg and Mezey (1988) and Marottoli et al (1994), on the other hand, also included cognitively impaired patients but failed to find a significant multivariate association. The former study did however achieve a significant univariate relationship.

The only study in the literature to report a relationship between gender and placement in institutional care was the one by Bonar et al (1990). The authors found that being female was predictive of institutionalisation at a univariate level but not multivariately.

In the current study sex failed to reach univariate significance with 12 month accommodation. It was observed however that a higher proportion of women who were resident in the community prior to their fracture were in institutional care at one year post-fracture.

Most of the studies investigating placement of patients six to 12 months after a hip fracture have used a cohort of patients from their own homes or from the 'community' and analysed the factors which predicted their return (Ceder et al 1980, Furstenberg and Mezey 1988, Bonar et al 1990, van der Sluijs and Walenkamp 1991). Van der Sluijs and Walenkamp (1991) subdivided their community population into patients from their own home and patients from an old persons home. The authors found that



patients from their own homes were more likely at a univariate level of analysis to be in their pre-fracture place of residence at one year post-fracture than patients from an old persons home. In the current study community residence was subdivided into : own home, home of a relative or friend, sheltered housing and residential care. Of the 100 patients who were in their own homes 79 were still there one year after the fracture. The course of the seven patients who were living with a relative or friend prior to their fracture was very different. Three were still there one year later, whilst one had moved into sheltered housing or residential care and the remaining three were in a nursing home or long stay care hospital. Of the 16 patients in sheltered housing or residential care 15 were still there one year post-fracture. These data suggest that patients who were in the more dependent forms of community care prior to their fracture were more likely to remain there which contrasts with the results of van der Sluijs and Walenkamp (1991).

The majority of hip fracture studies looking at placement six to twelve months post-fracture have found that living by oneself does not influence the outcome and this is in keeping with the results of the present study (Ceder et al 1980, Furstenberg and Mezey 1988, Bonar et al 1990, and van der Sluijs and Walenkamp 1991). Sernbo and Johnell (1993) however found that living with someone significantly predicted residence in the patient's own home 12 months post-fracture at a multivariate level of analysis.

In the current study physical health failed to reach univariate or multivariate significance with place of domicile one year post-fracture. This is in keeping with the literature. Ceder et al (1980) are the only researchers to find a predictive value of good general health for place of residence 12 months after a hip fracture and this was at the univariate level only. In the present study self-rated health was noted to be confounded by the total Barthel score, the total GDS score and the total AMT score. The 'number of categorised medical conditions' was also confounded by the total Barthel score and the total AMT score as well as by the baseline accommodation and 'how the patient managed on a daily basis'.

The evidence for cognitive status as being predictive of accommodation at one year post-fracture is more substantial than for physical health. The multivariate significance of mental impairment has been documented by Furstenberg and Mezey (1988), Bonar et al (1990), van der Sluijs and Walenkamp (1991), Sernbo and Johnell (1993) and Marottoli et al (1994). In the current study a better level of cognitive functioning as indicated by the total AMT score and the total GDS score were independently predictive of less dependent forms of accommodation at 12 months post-fracture. Marottoli et al (1994) however failed to show a predictive ability for depression which was assessed using the Center for Epidemiologic Studies Depression Scale.

The pre-fracture ability to perform the activities of daily living has been found to be predictive of less dependent forms of accommodation at one year post hip fracture at a univariate level (van der Sluijs and Walenkamp 1991) and at a multivariate level (Bonar et al 1990). Van der Sluijs and Walenkamp (1991) also reported the ability to perform the activities of daily living three weeks post-fracture to be predictive of less supported forms of accommodation at a univariate level. Ceder et al (1980) found a multivariate level of significance between the ability to perform the ADLs two weeks post-fracture and accommodation. The present study is supportive of these findings. Pre-fracture dependency was assessed by asking the patient to rate 'how they managed on a daily basis' and with the total Barthel score. Both variables attained independent significance.

The total Barthel score has a mobility sub-scale and this confounded the effect of the other first line mobility variable 'inside walking ability' which was entered as a potential first line predictor in the current study. The outside walking aid, average distance and maximum distance able to be walked prior to the fracture managed to attain univariate significance. Ceder et al (1980) found that the ability to walk two weeks post-operatively was predictive of less dependent forms of accommodation at one year post-fracture at a univariate level. Van der Sluijs and Walenkamp (1991) also showed this for walking ability three weeks post-operatively. Bonar et al (1990)

on the other hand failed to achieve a significant univariate result with walking status at discharge. Sernbo and Johnell (1993) reported a multivariate association between fewer walking aids and being in the pre-fracture place of accommodation at one year post-fracture.

In summary, age and pre-fracture accommodation were not surprisingly predictive of place of residence at one year post-fracture. Interestingly the co-residents and the physical health variables were not associated with long term placement at a multivariate level which seems counterintuitive but is in keeping with the literature. The current study confirmed the importance of cognitive functioning and pre-fracture dependency on future placement. It also reported the independent predictive value of depressive symptomatology for the first time. Reasonable prediction with the regression model for change in accommodation to a more dependent form, as indicated by the AUC for its ROC curve, was obtained. Prediction was less satisfactory for the regression model for actual accommodation at 12 months post-fracture.

#### **6.4 TWELVE MONTH DEPRESSION FOR SELF-REPORTING GROUP**

Due to the fact that there are no published figures on the reliability and validity of the short form of the Geriatric Depression Scale, as already discussed in section 5.4, the analysis for twelve month depression was carried out in two ways. Firstly the recommended cut-off point of five was used to make the GDS score at twelve months a binary variable. The GDS score was then also analysed as a continuous variable.

For both multivariate analyses the four patients who sustained a severe intervening medical event during their twelve month period of follow-up were excluded. Additionally one patient was not co-operative due to a personality disorder, four patients had clinical dementia, one patient was moribund and the data was missing for one patient. Altogether the data from 118 patients were available for analysis.

### **6.4.1 Univariate Analysis**

Refer to Appendix 12 for the important univariate results. Using a cut-off score of five, 44 of the 118 patients were classified as being depressed at 12 months.

None of the basic demographic variables or the fracture type were associated with being depressed at one year post-fracture. Of the general health parameters poorer self-rated general health at baseline was highly significantly related to depression as was impaired vision. Most of the psychological variables were significantly related to affective state at one year post-fracture as may have been expected, but cognitive status was not. Depression was also strongly related to the pre-fracture dependency measures. Patients who were able to walk without assistance were much less likely to be depressed at one year post-fracture compared to those who required some form of assistance. Patients were also significantly less likely to be depressed at the same stage if they had someone that relied on them for help with their problems, or if they were in contact with a greater number of relatives or if they had strong religious beliefs.

### **6.4.2 Multivariate Analysis**

A logistic regression analysis and a multiple regression analysis were performed, as outlined in the introductory section, to determine the predictors of depression when depression was analysed as a binary variable and as a continuous variable respectively using the GDS score.

#### **6.4.2.1 Selection of First Line Variables**

The selection of first line variables for the current study was guided by the work by Mossey et al (1989) as these researchers are the only ones to have specifically looked at the independent predictors of depression at one year post hip fracture. Depression in the study by Mossey et al (1989) was assessed using the Center for Epidemiological Studies Depression Scale (CES-D) and they used a highly selected consecutive series of hip fracture patients for their study. The patients had to be female, over the age of 59 years, resident in the community prior to their fracture and have been able to walk



independently or with a stick. The final selection criterion was that no post-surgical cognitive impairment had occurred. Of the 362 consecutive patients who fulfilled these criteria only 219 of the patients consented to be in the study which represents a response rate of 60%. A broad range of predictor variables were investigated covering basic sociodemographic parameters, health status, cognitive and psychosocial function, functional status and treatment variables. To cover most of these domains the following variables were used in the current study : age, sex, marital status, self-rated general health, the total number of categorised medical conditions, the total Geriatric Depression Scale score, the total Philadelphia Geriatric Center Morale Scale, 'how the patient rated how they managed on a daily basis', the total Barthel score, the type of main helper required, and the fracture type.

#### **6.4.2.2 Logistic Regression**

##### **6.4.2.2.1 First Line Variables in the Regression Model**

Baseline depression was the most significant independent predictor of depression one year after the fracture. The only other first line variable to enter the model at the 10% level of significance was the quality of life variable, the total PGCMS score. Patients with more depressive symptomatology and a lower quality of life at baseline were significantly more likely to be depressed at one year post-fracture. The regression model is presented in Table 6.7.

The same regression model was obtained using a stepwise backward logistic procedure indicating that the model was robust.

##### **6.4.2.2.2 Final Regression Model**

Thirty four second line variables were entered into the regression model with the two significant first line variables forced into it. Variables with missing values were not included. Vision, the previous number of hip fractures and whether the patient needed help to plan their day before their fracture attained significance at the 5% level. However the latter two were noted to have coefficients that had the wrong sign. Their significance was probably due to chance arising from multiple testing.



**Table 6.7** Twelve month depression logistic regression analysis

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

**a) Significant variables**

Variable	Coefficient	Standard error	P
Intercept	4.03	0.77	-
Total GDS score	-0.50	0.12	0.0001
Total PGCMS score	-0.16	0.088	0.072

**b) Non-significant variables**

Variable	P
Age	0.34
Sex	0.22
Marital status	0.58
General health	0.17
Managed on a daily basis	0.85
Total number of categorised medical conditions	0.62
Total Barthel score	0.48
Main helper	0.30
Fracture type	0.91

**2. Backward stepwise regression**

Same regression model generated as from forward procedure.

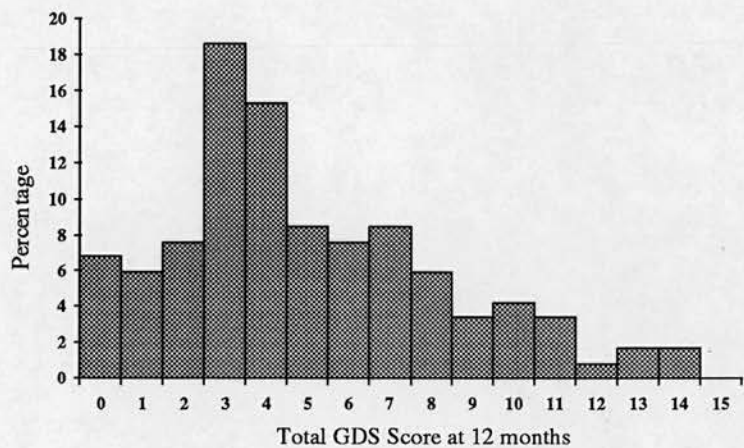
**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	2.13	1.03	-
Total GDS score	-0.55	0.13	0.0001
Total PGCMS score	-0.17	0.091	0.067
Vision	0.64	0.27	0.020

Consequently the second line model was re-run without these variables in it and vision was the only variable to enter at the 5% level. Poorer baseline vision was predictive of depression one year after a hip fracture. None of the third line variables attained the required 1% level of significance to enter the regression model. The final model is given in Table 6.7.

Every increment on the 16 point GDS scale at baseline, with a higher score being indicative of depression, was associated with an odds ratio of 1.72 of being depressed at one year post-fracture. The corresponding value for a single point increase in the 18 point baseline PGCMS score, indicating a poorer quality of life, was associated with an odds ratio of being depressed at twelve months of 1.18. Every point improvement in vision on its five point scale was however associated with a better odds ratio of being depressed, this being 0.53.

**6.4.2.3 Multiple Regression**



**Figure 6.5** 12 month Geriatric Depression Scale scores

The total GDS score at 12 months was not normally distributed and consequently required transformation if it were to be analysed using a multiple regression approach. See Figure 6.5.

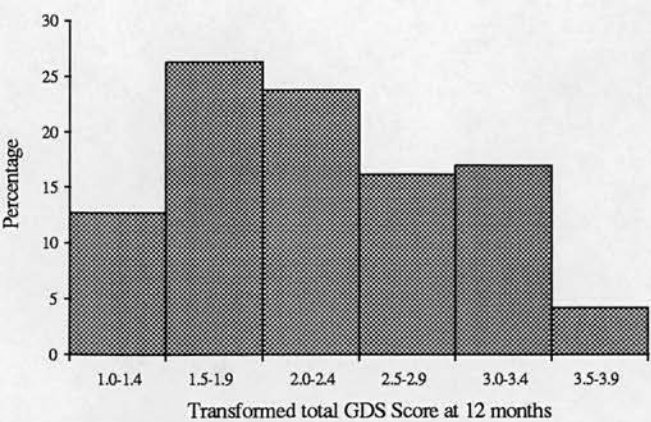
The transformation which minimised the skewness was the square root of (total GDS score at 12 months + 1). See Figure 6.6. The baseline GDS score was not transformed using the same formula because a plot of the scores against the transformed GDS scores at 12 months was essentially linear. Furthermore, for ease of usage of the prognostic index raw values for the baseline GDS score would be easier.

**6.4.2.3.1 First Line Variables in Regression Model**

The total GDS score and the total PGCMS score at baseline attained independent significance at the 10% level using a multiple regression approach with their directions being the same as for the logistic regression analysis. The model is given in Table 6.8. The same regression model was obtained when a backward stepwise procedure was employed indicating that the model was stable.

**6.4.2.3.2      Final Regression Model**

Of the second line variables vision and the strength of religious convictions attained independent significance at the 5% level and entered the model. Patients with better vision and stronger religious convictions were significantly less likely to have a high depression score at one year



**Figure 6.6** 12 month transformed Geriatric Depression Scale scores

post hip fracture. None of the third line variables achieved the 1% level of significance required for entry into the regression model. The final model is given in Table 6.8.

The model explained 48% of the variance which corresponded to a reasonably high value when dealing with biological data. It represents a multiple correlation coefficient of 0.69.

**6.4.2.4      Comparison of Multivariate Models**

The two models obtained from the ordered logistic approach and the multivariate approach were very similar indicating that not much information was lost when the total GDS score was simply treated as a binary variable. One extra predictor term was added into the regression model when the transformed values of the total GDS score were used compared to when it was analysed as a binary variable because the actual values were used which confers greater statistical power. The similarity of the terms in the two models suggests that it is likely that different cut points would yield the same predictors, but the percentage depressed would obviously change.

**Table 6.8** Twelve month depression multiple regression analysis

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

<b>a) Significant variables</b>			
Variable	Coefficient	Standard error	P
Intercept	1.56	0.11	-
Total GDS score	0.11	0.021	0.0001
Total PGCMS score	0.042	0.018	0.018
<b>b) Non-significant variables</b>			
Variable	P		
Age	0.94		
Sex	0.97		
Marital status	0.74		
General health	0.20		
Total number of categorised medical conditions	0.32		
Managed on a daily basis	0.77		
Total Barthel score	0.26		
Main helper	0.13		
Fracture type	0.73		

**2. Backward stepwise regression**

Same model generated with forward stepwise procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	2.23	0.21	-
Total GDS score	0.10	0.020	0.0001
Total PGCMS score	0.041	0.017	0.014
Religion	-0.20	0.056	0.0005
Vision	-0.11	0.043	0.011

6.4.3 Prediction in Practice

A clinical example of the prediction of depression at 12 months post-fracture will now be given to illustrate the use of the logistic regression model which is given in section 6.4.2.2.2. A patient with a baseline GDS score of five with a PGCMS score of seven

Table 6.9 Predicted versus observed 12 month depression

Predicted probability	Observed frequency			Observed probability
	Depressed	Not depressed	Total	
0.00-0.09	1	26	27	0.04
0.10-0.19	3	18	21	0.14
0.20-0.29	4	12	16	0.25
0.30-0.39	4	7	11	0.36
0.40-0.49	2	3	5	0.40
0.50-0.59	4	3	7	0.57
0.60-0.69	5	3	8	0.63
0.70-0.79	3	1	4	0.75
0.80-0.89	6	0	6	1.00
0.90-1.00	12	1	13	0.92

who had severely impaired vision may be calculated to have a y value of -1.81. This corresponds to a probability of depression at 12 months of 0.86. Referring to Table 6.9 it can be seen

that a predicted probability in the range from 0.80 to 0.89 corresponds to an observed probability of 1.00 thereby giving support to the reasonableness of the model. The predicted probabilities for each category in Table 6.9 were comparable to the observed proportions of patients who were depressed at 12 months post-fracture.

Good predictive capacity was obtained for the logistic regression model as indicated by an AUC of 0.88 for its ROC curve as illustrated in Figure 6.7. An 80% chance of correctly identifying depression was associated with a 77% chance of correctly predicting a non-depressed state.

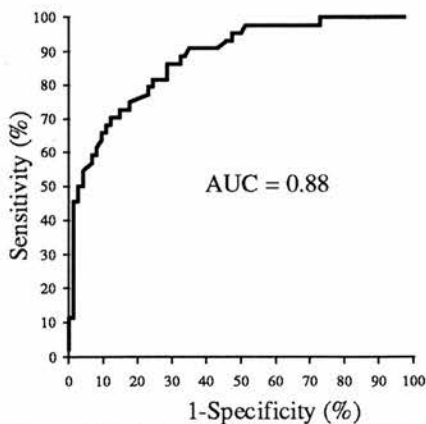
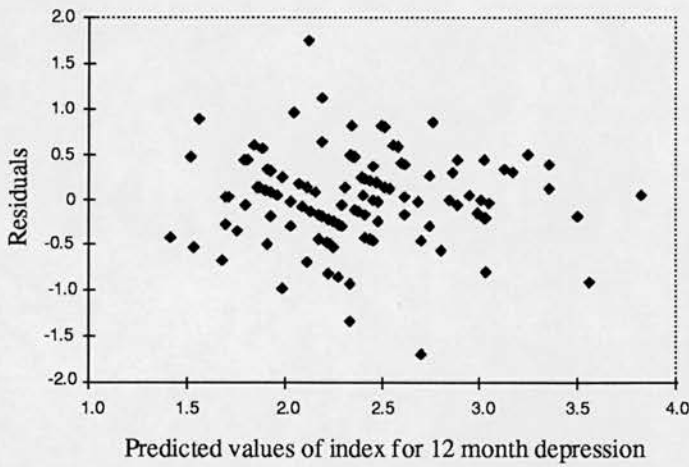


Figure 6.7 12 month depression ROC curve

Figure 6.8 shows that the assumptions for the multiple regression model when depression was analysed as a continuous variable were met as the residuals are



normally and identically distributed. Further detail about this graphical approach is given in section 5.4.3.



**Figure 6.8** Residual plot for predicted values of index for 12 month depression

#### 6.4.4 Discussion

The current study confirmed the univariate findings of Mossey et al (1989) that baseline depression and self-rated health were significantly associated with depression at one year post-fracture although it failed to demonstrate a significant

relationship with the total number of medical conditions. The ability to perform the primary and instrumental activities of daily living were found to be significantly associated with depression one year later in the current study only at a univariate level. However, Mossey et al (1989) constructed a physical functioning variable, which was derived using a principal components analysis based on the ADLs and walking ability, and this variable was found to be significantly associated with depression twelve months after the hip fracture at a multivariate level. The present study failed to achieve significance for any of the physical functioning parameters at a multivariate level as they were confounded by the psychological variables. Vision however did attain independent significance in both the logistic regression and the multiple regression analyses. This is a new finding and may simply represent the result of multiple testing. Further research is required to confirm its predictive role.

The current study confirmed the importance of baseline depression as being a predictor of future depression, in addition to the psychological variables quality of life, as gauged by the total PGCMS score, and the strength of religious convictions. An additional finding in the present study was that if someone relied on the patient for

emotional support the patient was significantly less likely to be depressed at one year post-fracture at a univariate level of analysis.

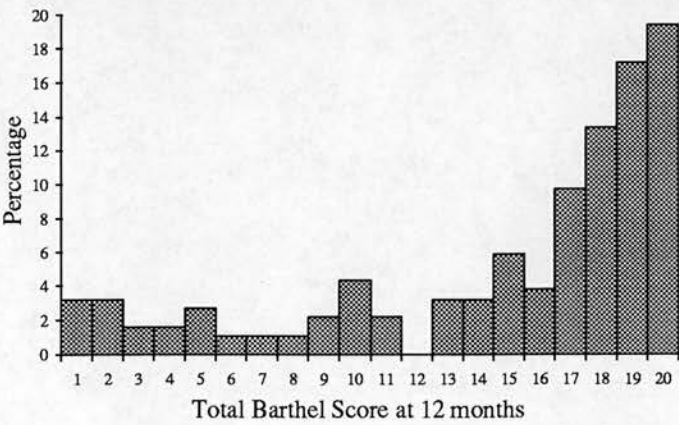
In summary, the current study confirmed the importance of baseline depression in predicting depression at one year post-fracture. Two other psychological variables also achieved independent significance these being the total PGCMS score and religious convictions and this is the first time they have been reported in the hip fracture literature. The latter variable attained significance when a multiple regression approach was employed. The only other independent predictor that has been identified in the literature has been a composite physical functioning variable but the importance of this was not verified in the current study. In the present study vision was found to be a predictor of future depression which is a new finding. It was interesting to note that treating the twelve month GDS score as a binary variable, with a cut-off point of five, and as a continuous variable did not change the predictors appreciably. The prediction obtained from the logistic regression model for 12 month depression was good as indicated by an AUC of 0.88.

**6.5 TWELVE MONTH DEPENDENCY**

As for the one month outcome variable the predictors for both the self-reporting group and the whole study population for dependency were obtained. The analysis for the latter group was expanded to assess the effect of different types of statistical analyses on the derived set of predictors. Four patients who sustained severe medical events interfering with their rehabilitation were excluded from the analyses.

**6.5.1 Self-reporting Group**

The distribution of the Barthel scores was markedly skewed to the left as was the case for the one month scores. See Figure



**Figure 6.9** 12 month Barthel Index scores for self-reporting group

6.9. The classification of the scores for the ordered logistic regression was the same as for the one month analysis.

#### **6.5.1.1      Univariate Analysis**

The important univariate results are presented in Appendix 12. The only baseline demographic variable to attain significance with 12 month dependency was age, with advanced age being associated with increased dependency. Patients who sustained an extracapsular fracture had higher dependency levels on the whole than patients who had suffered an intracapsular fracture but this difference did not attain statistical significance. Interestingly none of the general health measures were significantly related to 12 month dependency apart from the number of hospitalisations in the preceding year. A higher total Geriatric Depression score, indicating depression, was highly significantly associated with increased dependency at 12 months post-fracture. The activities of daily living and mobility were very highly significantly associated with 12 month dependency. Two social variables reflecting dependency, namely 'how the patient managed on a daily basis' and 'how the patient managed on their own' reached statistical significance. With the latter variable it should be noted that 122 of the 124 patients were in the 'yes' category thereby limiting its usefulness as a predictor.

#### **6.5.1.2      Multivariate Analysis**

An ordered logistic regression analysis was undertaken.

##### **6.5.1.2.1      Selection of First Line Variables**

Age has been widely used as a potential predictor for dependency six to 12 months after a hip fracture, in community-residing or rehabilitation series of patients and was included as a potential predictor in the present study (Katz et al 1967, Cobey et al 1976, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992). Gender has been less extensively investigated than age and has been found not to be predictive of future dependency but despite this was included as a potential predictor because of its basic epidemiological importance (Magaziner et al 1989, Marottoli et al 1992). The

pre-fracture place of residence has not been documented to be predictive of future dependency but was nonetheless included in order to further assess its role in hip fracture patients (Mossey et al 1989, Marottoli et al 1992). The evidence for pre-fracture co-morbidity influencing future dependency levels is inconsistent (Katz et al 1967, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992). To help clarify this situation the self-rated 'general health' variable and the 'total number of categorised medical conditions' were included as potential predictors in the current study. Firmer evidence exists in the literature for cognitive impairment impeding functional recovery (Cobey et al 1976, Baker et al 1979, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992). To further assess this relationship the total AMT score and total GDS score were incorporated into the present study as potential predictors. Pre-fracture dependency has been found to be predictive of future dependency levels, as would be expected (Cobey et al 1976, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992). In the present study the baseline variables 'how the patient managed on a daily basis', the total Barthel score, the 'type of walking aid required inside' and the 'main helper required' were included to cover patient dependency. The predictive role of fracture type has also been assessed in relationship to future dependency with the general consensus being that it is not a significant independent predictor of future functioning (Cobey et al 1976, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992, Keene et al 1993). Fracture type was included into the potential battery of first line variables to investigate this relationship further.

#### **6.5.1.2.2      First Line Variables in the Regression Model**

The total Barthel score entered as the most significant variable into the model followed by age and fracture type. However when the second line variables were added in the Barthel self-care subscale also entered the model. As a result of this the first line model was re-run with the total Barthel score replaced by its two components the self-care subscale and the mobility subscale. Four terms then entered the regression model and these in order of entry were : Barthel self-care subscale, age, inside walking aid and fracture type. The Barthel mobility subscale was noted to be

strongly confounded by the inside walking aid. The first line model indicated that patients who were older, were poorer at their self-care, required assistance with walking, or had sustained an extracapsular fracture were more likely to be dependent one year after their fracture. The regression model is given in Table 6.10 along with the non-significant variables.

The same model was obtained when a backward stepwise procedure was performed indicating that the model was robust.

**Table 6.10** Twelve month dependency ordered logistic regression analysis for self-reporting group

- A. FIRST LINE PREDICTOR VARIABLES
1. Forward stepwise regression
- a) Significant variables

Variable	Coefficient	Standard error	P
Intercept 1	-0.050	2.50	-
Intercept 2	2.20	2.57	-
Intercept 3	4.23	2.61	-
Intercept 4	5.72	2.60	-
Total Barthel self-care subscale score	-1.07	0.18	0.0001
Age	0.082	0.023	0.0003
Inside walking aid	0.28	0.11	0.0073
Fracture type	0.85	0.35	0.016

b) Non-significant variables

Variable	P
Sex	0.81
Accommodation	0.76
General health	0.61
Total number of categorised medical conditions	0.10
Total AMT score	0.25
Total GDS score	0.25
Managed on a daily basis	0.57
Total Barthel mobility subscale score	0.83
Main helper	0.80



**Table 6.10 (continued)** Twelve month dependency ordered logistic regression analysis for self-reporting group

2. Backward stepwise regression  
The same model was generated as with the forward stepwise procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-0.11	2.50	-
Intercept 2	2.17	2.56	-
Intercept 3	4.25	2.60	-
Intercept 4	5.77	2.60	-
Total Barthel self-care subscale score	-0.96	0.19	0.0001
Age	0.080	0.023	0.0006
Inside walking aid	0.18	0.12	0.12
Fracture type	0.87	0.35	0.014
Maximum supported walking distance	-0.20	0.15	0.049

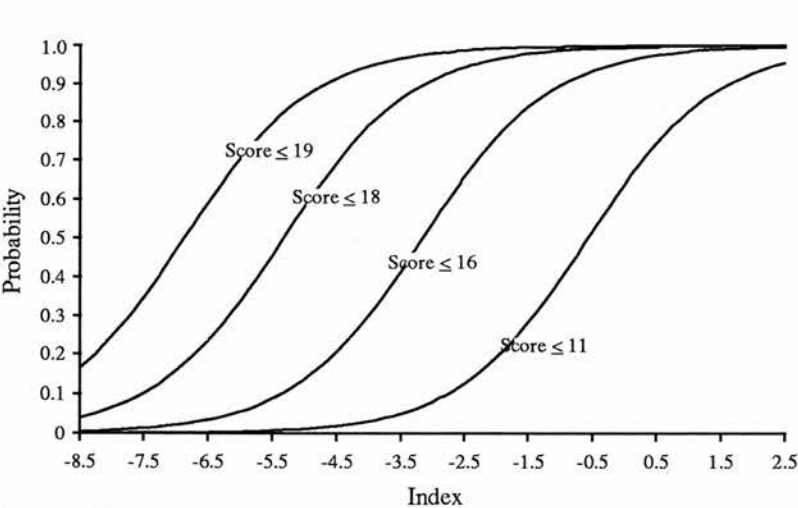
**6.5.1.2.3 Final Regression Model**

When the second line variables were entered into the regression model, with the significant first line variables forced into it, only the maximum supported walking distance attained independent significance at the 5% level. It was noted that the significance level of the inside walking aid rose to 0.12 when the maximum supported walking distance entered the model due to the confounding effect of this variable. No third line variables entered the regression model. The final regression model is given in Table 6.10.

Sustaining an extracapsular fracture was associated with a 2.40 fold increase in the odds ratio of moving into a more dependent category whilst each decade increase in age was associated with a corresponding odds ratio of 2.21. Every increment in walking aid dependency on the 11 point scale was associated with a 1.20 odds ratio of moving into a more dependent category at 12 months post-fracture. Reduced odds ratios of 0.38 and 0.75 were associated with a one point improvement in the Barthel self-care subscore and the maximum supported walking distance which had 13 and 5 categories respectively.

6.5.1.3 Prediction in Practice

Figure 6.10 illustrates the probability of dependency for any given value of the index generated from the ordered logistic regression model. It can be seen approximately that an index value of -2.37 corresponds to a probability of 0.15 of having a total



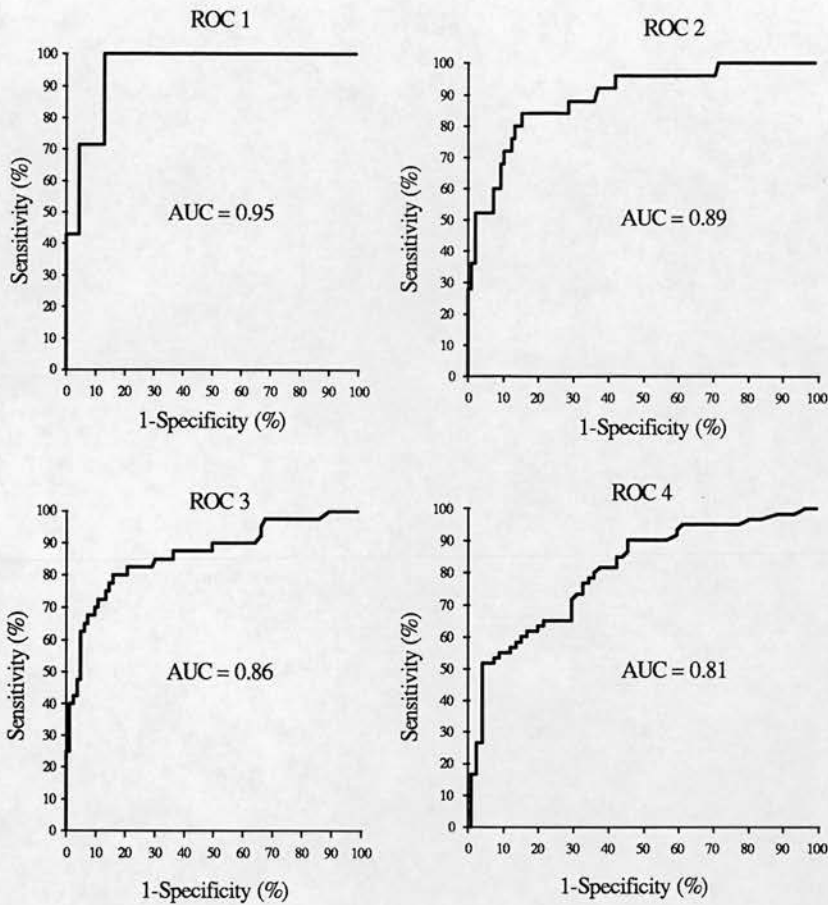
Barthel score of 11 or less, and probabilities of 0.70, 0.96 and 0.99 for scores of 16 or less, 18 or less, and 19 or less respectively. The baseline

**Figure 6.10** 12 month dependency sigmoid curves for self reporting group characteristics of a patient to generate an index value of -2.37 to put the example into a clinical perspective may be as follows : age of 80 years; Barthel self-care subscore of 10; two sticks required to walk inside; maximum walking distance of 50-100 yards outside; and sustaining an intracapsular fracture. Reviewing Table 6.11 it can be seen that an index value of in the range -4.00 to -2.01 corresponds to observed probabilities of 0.12, 0.47, 0.88 and 0.94 for total Barthel scores of less than or equal to 11, 16, 18 and 19 respectively.

Four ROC curves were constructed from the five categories used for the ordered logistic regression analysis and these are presented sequentially in Figure 6.11. The AUC ranged from 0.81 to 0.95. The

**Table 6.11** Prognostic index values cross tabulated against 12 month dependency for self reporting group

Index	Observed frequency for Barthel score					Total
	0-11	12-16	17-18	19	20	
-10.00<-8.01	0	0	0	0	1	1
-8.00<-6.01	0	1	10	11	26	48
-6.00<-4.01	0	7	17	19	4	47
-4.00<-2.01	2	6	7	1	1	17
-2.00<0.01	4	4	1	0	0	9
0.00<1.99	0	0	0	0	0	0
2.00<3.99	1	0	0	0	0	1
4.00<5.99	0	0	0	0	0	0



**Figure 6.11** 12 month dependency serial ROC curves for self reporting group

best prediction was obtained for predicting patients in the dependent category, that is a score of 11 or less, versus patients in the independent category. A sensitivity of 80% was associated with a specificity of 87%. Poorest prediction was obtained for

patient with a Barthel score of less than or equal to 19 compared to a score of 20. From the fourth ROC curve it can be seen that a sensitivity of 80% was associated with a specificity of 64%.

#### 6.5.1.4 Discussion

The importance of age in predicting dependency one year after a hip fracture was confirmed in the present study (Katz et al 1967, Cobey et al 1976, Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992). It was the second most important predictor of dependency in the study. Gender and pre-fracture accommodation were found to be not predictive of dependency which is in keeping with the literature (Magaziner et al 1989, Marottoli et al 1992). The only study to report a significant association of gender with dependency was the one by Magaziner et al (1990). These authors reported a negative effect of male sex on walking ability at a multivariate

level. In the current study accommodation was noted to be strongly confounded by the Barthel self-care subscore.

The present study is the first to report a significant multivariate association between fracture type and one year dependency in hip fracture community patients. An extracapsular fracture was associated with increased dependency. Cobey et al (1979), Jette et al (1987), Magaziner et al (1990) and Mossey et al (1990) all failed to find a significant relationship.

The lack of a significant relationship with comorbidity and dependency at one year post-fracture in the present study agrees with the findings of Jette et al (1987), Magaziner et al (1990) and Marottoli et al (1992). Significant univariate relationships have been reported by Mossey et al (1989) for self-rated general health, number of pre-existing medical conditions and the number of serious medical conditions. None of these associations achieved multivariate significance. It should be noted that Mossey et al (1989) used a very highly selected study population for their research which may limit the generalisability of their results. To be eligible for the study the patients had to be female, Caucasian, ambulatory prior to their fracture and resident in the community as outlined in section 6.4.2.1. The other study to report a significant univariate relationship with concomitant disease and dependency in the literature was the early study performed by Katz et al in 1967. The 130 rehabilitation patients were followed up for three and a half years.

Cognitive impairment has been found to be predictive of increased dependency in community patients at a multivariate level by Magaziner et al (1990) and Mossey et al (1990). Univariate associations have also been found by Cobey et al (1976) and Marottoli et al (1992) but were not replicated in the current study. The literature also suggests that there is an association between baseline depression and increased dependency at one year post-fracture. Mossey et al (1990) and Marottoli et al (1992) both found significant associations at a multivariate level. Cobey et al (1976) and Jette et al (1987) reported poor pre-fracture 'emotional state' being associated with

poorer functioning at a univariate level. In the present study a significant univariate relationship was found with depression, as gauged by the total GDS score and dependency at one year post-fracture, but not for a poorer quality of life as measured by the total PGCMS score.

The role of pre-fracture dependency in predicting dependency six to 12 months after a hip fracture is clearly documented in the literature. Multivariate relationships have been reported by Jette et al (1987), Mossey et al (1990) and Marottoli et al (1992). In the current study the Barthel self-care subscale at baseline was the most important independent predictive factor for dependency at one year post-fracture. Two other indicators of dependency reached multivariate significance in the present study. These were the type of walking aid required inside and the maximum distance able to be walked with support. Pre-fracture walking ability consequently had a very important predictive role for dependency at one year post-fracture as gauged by the total Barthel score. This was not surprising as the Barthel Index has a mobility subscale which accounts for 30% of the total score.

In summary, the predictors of twelve month dependency in the current study were not surprisingly a subset of variables which are largely indicative of dependency, namely the Barthel self-care subscore, inside walking aid and the maximum supported walking distance, and confirms what has been reported in the literature. The predictive role of age but not comorbidity in the present study also confirms the literature. The lack of predictiveness of cognitive state in the current study contrasts however with the main body of literature. A new finding in the present study is the predictive role of fracture type on twelve month dependency. The ordered logistic regression model offered good predictive capacity as indicated by AUC for the serial ROC curves which ranged from 0.81 to 0.95.

### **6.5.2 Whole Study Population**

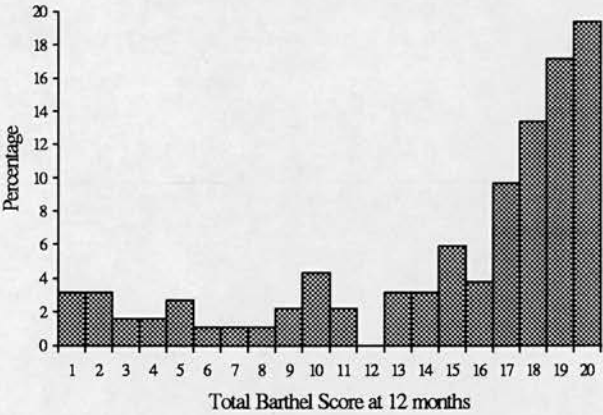
The classification for the univariate and ordered logistic regression analyses is identical to that used for the corresponding one month dependency analysis. Refer to



section 5.5.2. The distribution of the total Barthel scores for the whole study population is given in Figure 6.12.

**6.5.2.1 Univariate Analysis**

The important univariate results are presented in Appendix 12 with total Barthel score analysed as an ordered categorical variable. Very highly significant relationships were obtained with some of the demographic variables and most of the general physical and mental health parameters. Similar associations were also obtained for the dependency and mobility variables. The social variables did not uniformly attain univariate significance.



**Figure 6.12** 12 month Barthel Index scores for whole study population

**6.5.2.2 Multivariate Analysis**

In this section three different types of multivariate analyses will be presented so that the effect of the type of statistical approach on the derived predictors can be formally assessed. The results for the ordered logistic regression procedure, in which the order of entry of the baseline variables was stratified, will be presented first. This will be followed by two multiple regression analyses. In the first of the multiple regression analyses the baseline variables were not stratified whilst in the second they were.

**6.5.2.2.1 Selection of First Line Variables**

The selection of the first line variables for the current analysis was largely guided by the results of the studies that have used community-residing residents only as little is reported in the literature about predictors of dependency in unselected series of hip fracture patients. The three comprehensive studies that have assessed dependency in community residing individuals at six to 12 months post-fracture are detailed in section 6.5.1.2.1 (Mossey et al 1989, Magaziner et al 1990, Marottoli et al 1992).

Other studies which have used consecutive series of patients have applied other selection criteria thereby limiting the generalisability of their results. For example, Katz et al (1967) and Barnes and Dunovan (1987) used rehabilitation patients only. Cobey et al (1976) recruited patients who were previously independent, had no cognitive deficit and had no diseases likely to prevent rehabilitation. Larsson et al (1990) restricted themselves to patients with extracapsular fractures.

In the literature three studies have been reported which have used an unselected series of patients to assess dependency at six to 12 months post-fracture (Baker et al 1979, Jette et al 1987, Keene et al 1993). The role of age, sex and comorbidity have been investigated by Jette et al (1987). Mental health parameters have been examined by Baker et al (1979) and Jette et al (1987). Pre-fracture physical functioning, mobility and fracture type have also been assessed in relation to future dependency (Jette et al 1987, Keene et al 1993).

The final selection of baseline variables for the whole study population was identical to that used for self-reporting group. The only exception was the substitution of the study status variable for the total GDS score as the total GDS score was not a variable that was used for the informant-requiring group.

#### **6.5.2.2.2      Ordered Logistic Regression**

##### **6.5.2.2.2.1      First Line Variables in the Regression Model**

Five first line variables entered the regression model at the 10% level of significance. In order of entry these variables were : total Barthel score, study status, 'how the patient managed on a daily basis', age and accommodation. The regression model is given in Table 6.12 as well as the non-significant first line variables.

However when the backward stepwise procedure was performed the total AMT score stayed in the model instead of study status. Review of the log likelihoods of the two models indicated that the regression model with study status in it provided a slightly better fit of the data. However as the total AMT score is a simpler and more

**Table 6.12** Twelve month dependency ordered logistic regression analysis for whole study population

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression - significant variables**

Variable	Coefficient	Standard error	P
Intercept 1	-1.39	1.81	-
Intercept 2	-0.32	1.83	-
Intercept 3	0.88	1.85	-
Intercept 4	2.65	1.87	-
Intercept 5	4.39	1.87	-
Intercept 6	5.60	1.87	-
Total Barthel score	-0.41	0.070	0.0001
Study status	-1.15	0.38	0.0027
Managed on a daily basis	0.59	0.20	0.0028
Age	0.048	0.018	0.0071
Accommodation	0.24	0.11	0.029

**2. Backward stepwise regression - significant variables**

The total AMT score entered the backward regression model instead of category. Although the forward model gave a marginally better fit than the backward model because the AMT score is a simpler variable than category it was selected for the definitive model for the first line variables.

Variable	Coefficient	Standard error	P
Intercept 1	-0.92	1.85	-
Intercept 2	0.15	1.86	-
Intercept 3	1.39	1.89	-
Intercept 4	3.17	1.91	-
Intercept 5	4.88	1.92	-
Intercept 6	6.08	1.92	-
Total Barthel score	-0.40	0.070	0.0001
Total AMT score	-0.18	0.057	0.0021
Managed on a daily basis	0.63	0.20	0.0013
Age	0.047	0.018	0.0094
Accommodation	0.24	0.11	0.032

**3. Forward stepwise regression - non-significant variables when the total AMT score forced into the model**

**Table 6.12 (continued)** Twelve month dependency ordered logistic regression analysis for whole study population

Variable	P
Sex	0.21
Study status	0.18
General health	0.90
Total number of categorised medical conditions	0.95
Inside walking aid	0.59
Main helper	0.94
Fracture type	0.11

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-3.08	2.14	-
Intercept 2	-2.04	2.14	-
Intercept 3	-0.81	2.15	-
Intercept 4	1.00	2.17	-
Intercept 5	2.85	2.17	-
Intercept 6	4.15	2.16	-
Total Barthel score	-0.25	0.082	0.0025
Total AMT score	-0.19	0.058	0.0013
Managed on a daily basis	0.34	0.21	0.11
Age	0.045	0.018	0.014
Accommodation	0.17	0.11	0.13
Clackmannan self-care subscale score	0.20	0.081	0.013
Maximum supported walking distance	-0.24	0.11	0.037

standardised variable than study status the pragmatic decision was taken to include the total AMT score into the regression model at the expense of study status. Patients who were younger, lived in less dependent forms of accommodation prior to their fracture, and were less dependent were significantly less likely to be dependent at one year post-fracture.

#### **6.5.2.2.2 Final Regression Model**

Adding in the second line variables into the regression model resulted in the Clackmannan self-care subscore being entered followed by the 'maximum distance able to be walked with support'. Patients with better baseline self-care abilities and less walking impairment were significantly less likely to be dependent at twelve months post-fracture. No third line variables attained the necessary 1% level of significance required for inclusion. The final regression model is given in Table 6.12.

For each decade increase in age the odds ratio of being in a more dependent category was 1.57. The increased odds ratio for an increment in accommodation, 'how the patient managed on a daily basis', and the Clackmannan self-care subscore were 1.18, 1.40 and 1.22 respectively. An increment in the total Barthel score and the total AMT score were associated with a reduced odds ratio of 0.78 and 0.79 of moving into a more dependent category.

#### **6.5.2.2.3 Unstratified Multiple Regression**

In this analysis the baseline variables were all entered simultaneously and an inclusion significance level of 5% was set as this is the level most commonly used for statistical analyses. All baseline variables with missing values, apart from the total AMT score which had only one missing value, were excluded from the analysis. Six variables entered the regression model and they were in order of entry : Barthel self-care subscale, Clackmannan self-care subscale, study status, age, maximum supported walking distance and fracture type. Patients who were younger, self-reporting, had better self-care, were less impaired in their walking ability at baseline , or who had sustained an intracapsular fracture were significantly less likely to be in a more dependent category at one year post-fracture. The regression model is given in Table 6.13. It explained 67% of the variance which corresponded to a multiple correlation coefficient of 0.82.



**Table 6.13** Twelve month dependency unstratified multiple regression analysis for whole study population

A. FINAL MODEL

Variable	Coefficient	Standard error	P
Intercept	5.54	1.06	-
Barthel self-care subscale score	0.22	0.056	0.0001
Clackmannan self-care subscale score	-0.13	0.047	0.0065
Study status	0.76	0.21	0.0005
Age	-0.029	0.010	0.0051
Outside walking aid	-0.10	0.035	0.0042
Fracture type	-0.35	0.16	0.033

**6.5.2.2.4**      Stratified Multiple Regression

**6.5.2.2.4.1**    First Line Variables in the Regression Model

Six first line variables entered the multiple regression model at the 10% level of significance. These variables, in the order they entered the model were : total Barthel score, total AMT score, how the patient managed on a daily basis, accommodation, sex and study status. Male self-reporting patients from less supported forms of accommodation with better cognition and less pre-fracture dependence were significantly less likely to be in a more dependent category at one year post-fracture. The regression model is given in Table 6.14. The probabilities of the first line variables which did not attain the required 10% level of significance required for entry are listed in Table 6.14.

When a backward stepwise procedure was performed the same regression model was obtained indicating that the model was robust.

**6.5.2.2.4.2**    Final Regression Model

The regression analysis was then extended to include the potential second line variables, with the significant first line variables forced into the model. This resulted in the Clackmannan self-care subscale and the number of medications being entered into the model. However it was noted that the number of medications had the wrong

**Table 6.14** Twelve month dependency stratified multiple regression analysis for whole study population

**A. FIRST LINE PREDICTOR VARIABLES**

**1. Forward stepwise regression**

<b>a) Significant variables</b>			
Variable	Coefficient	Standard error	P
Intercept	0.87	2.24	-
Total Barthel score	0.65	0.10	0.0001
Total AMT score	0.27	0.14	0.048
Managed on a daily basis	-1.05	0.34	0.0024
Accommodation	-0.41	0.20	0.036
Sex	1.52	0.64	0.018
Study status	1.60	0.92	0.082

<b>b) Non-significant variables</b>	
Variable	P
Age	0.52
General health	0.84
Total number of categorised medical conditions	0.85
Inside walking aid	0.99
Main helper	0.93
Fracture type	0.19

**2. Backward stepwise regression**  
Same regression model generated as from forward procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	4.35	2.68	-
Total Barthel score	0.50	0.12	0.0001
Total AMT score	0.24	0.13	0.072
Managed on a daily basis	-0.76	0.36	0.038
Accommodation	-0.35	0.20	0.076
Sex	1.35	0.63	0.035
Study status	1.61	0.91	0.077
Clackmannan self-care subscale score	-0.30	0.13	0.022

sign for its coefficient because it indicated that patients who were on more medications were less likely to be dependent at one year post-fracture. As a consequence the analysis was repeated without the number of medications in it. The Clackmannan self-care subscale was the only second line variable to enter the model. Patients who were better able to manage their own self-care were less likely to be in a more dependent category at one year post-fracture. Adding the third line variables to the analysis did not result in any more terms entering the regression model. The final regression model is given in Table 6.14 and it explained 69% of the variance and has a multiple correlation coefficient of 0.83.

#### **6.5.2.2.5      Comparison of Regression Models**

The significant predictor variables obtained with the ordered logistic regression (OLR) procedure and the stratified multiple regression procedure (SMR) were very similar. The two regression models had five identical dependent variables out of a total of seven variables in each of the models. These variables were : total Barthel score, total AMT score, how the patient managed on a daily basis, accommodation and Clackmannan self-care subscale. The OLR model also included age and the maximum supported walking distance whilst the SMR model had gender and study status. The order in which the variables entered the two models was very similar.

Reviewing the models obtained using unstratified multiple regression (UMR) and SMR showed there was much greater disparity between the models than had occurred when the OLR and SMR models were compared with each other. The reason for this difference is that many of the potential first line variables did not enter the UMR model due to confounding by the other 26 variables that were entered concurrently into the analysis. The UMR procedure yielded a model with only five dependent variables in it compared to the seven achieved with the stratified multiple regression procedure. The two models only had the study status and the Clackmannan self-care subscale in common. The UMR model also included age, the total Barthel self-care subscale, the outside walking aid and fracture type. The SMR model included the total Barthel score which makes more sense than simply having the self-care subscore

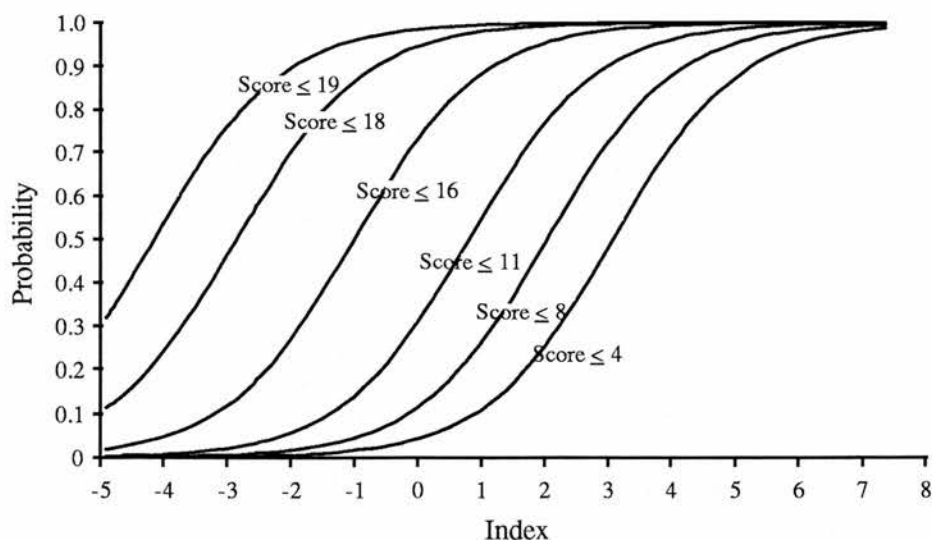
in it, as in the UMR model, for predicting the total Barthel score at 12 months post-fracture. The SMR model also had the total AMT score, 'how the patient managed on a daily basis', accommodation, and gender entered into it. Despite the fact that the predictive models looked quite different for the UMR and SMR approaches they did in fact explain a similar amount of variance. The SMR model accounted for 69% of the variance which was only 2% more than the UMR model.

The main reason for using the different statistical procedures for analysing twelve month dependency was to see whether there would be any clear cut benefit obtained from using a particular approach for predictive purposes. The models obtained with the OLR approach and the SMR procedure were in fact very similar. This raises the issue of whether it is useful to categorise the Barthel score in order to enhance its prediction at 12 months post-fracture.

### 6.5.2.3 Prediction in Practice

Figure 6.13 summarises the probability of being in a particular Barthel score range or one lower for the full range of index values taken by the regression model. A patient who was 78 years of age, in the SRG of patients, had a Barthel self-care subscore of 10 and a Clackmannan self-care subscore of 5 prior to her fracture, who used a zimmer to walk outside and who sustained an intracapsular fracture can be calculated to have an index score of -0.70. Refer to Appendix 11 for the numerical values for the categorical variables used in the regression model. It can be seen from Figure 6.13 that an index value corresponds to probabilities of 0.02, 0.07, 0.18, 0.57, 0.89 and 0.96 of having a Barthel score of less than or equal to 4, 8, 11, 16, 18 and 19 respectively. In other words this patient would have an 18% chance of being dependent, corresponding to a Barthel score of 11 or less, at 12 months post-fracture.

In Table 6.15 the index values are tabulated against the actual Barthel category score at 12 months post-fracture. A Spearman's correlation coefficient of -0.80 was obtained for the index values and the categorised values of the total Barthel score indicating a strong relationship between the two. The patient described in the



**Figure 6.13** 12 month dependency sigmoid curves for whole study population

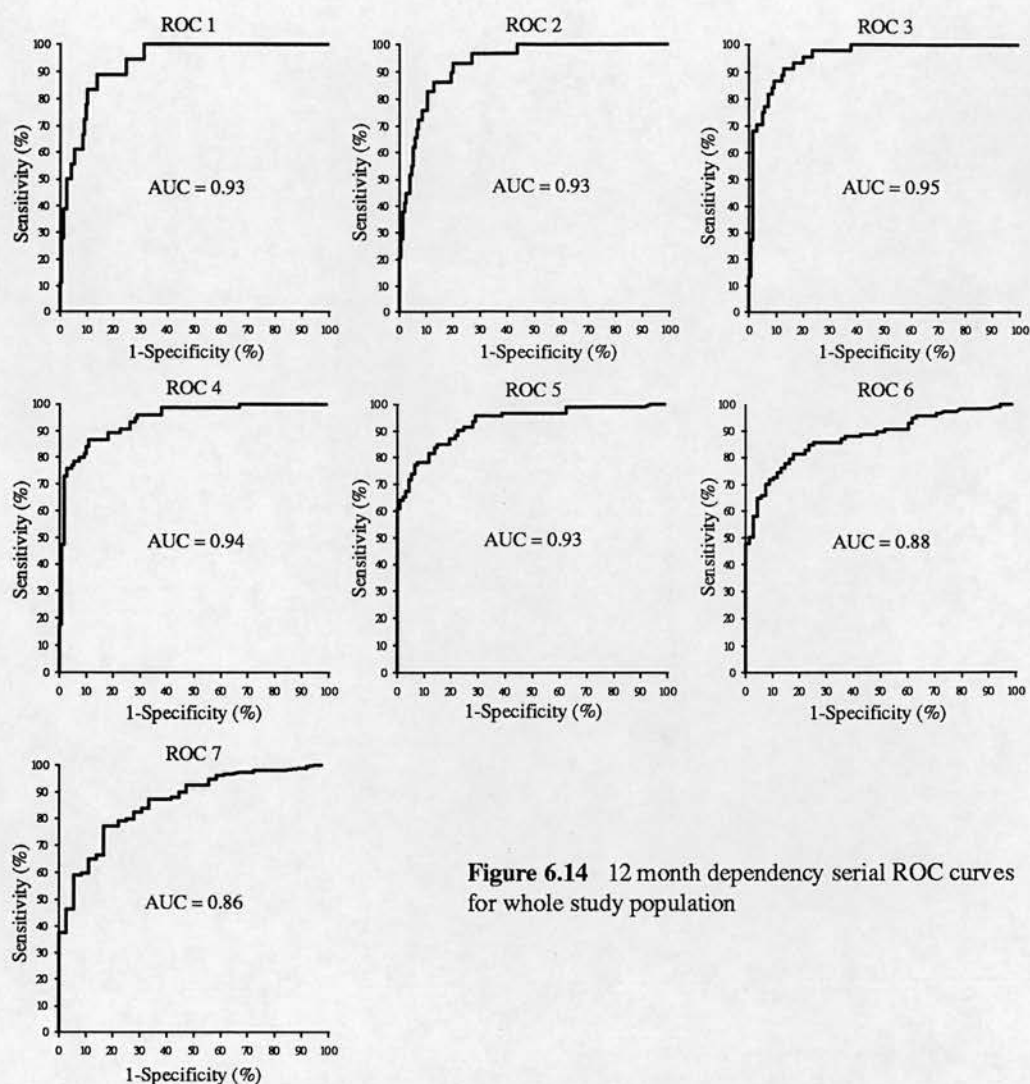
previous paragraph with an index value in the range -2.00 to less than 0 can be calculated to have probabilities of 0.057, 0.086, 0.14, 0.45, 0.86 and 0.94 of having Barthel scores of less than or equal to 4, 8, 11, 16, 18 and 19 respectively. These probabilities correspond to those derived from the sigmoid curves in Figure 6.13.

Excellent prediction was obtained using the ordered logistic model for the prediction of dependency at 12 months as indicated by the serial ROC curves presented in Figure 6.14. The AUC ranged from 0.86 to 0.95. The best prediction was obtained for ROC curve 3 which is comparing dependence with independence, that is scores of 11 or less with scores of 12 or more. An 80% chance of correctly predicting dependency is associated with a 93% chance of correctly predicting independence. ROC curve 7

**Table 6.15** Prognostic index values cross-tabulated against observed 12 month dependency for whole study population

Index	Observed frequency for Barthel score							Total
	0-4	5-8	9-11	12-16	17-18	19	20	
-6.00-<-4.01	0	0	0	0	5	6	17	28
-4.00-<-2.01	0	1	1	7	22	23	17	71
-2.00-<0.01	2	1	2	11	14	3	2	35
0.00-<1.99	5	5	8	11	1	0	0	30
2.00-<3.99	5	3	5	0	1	0	0	14
4.00-<5.99	4	1	0	1	0	0	0	6
6.00-<7.99	2	0	0	0	0	0	0	2





**Figure 6.14** 12 month dependency serial ROC curves for whole study population

exhibited the poorest predictive capacity with an 80% chance of correctly predicting a patient would have a score of 19 or less being associated with a 75% chance of correctly predicting a score of 20.

#### 6.5.2.4 Discussion

The discussion for 12 month dependency will be limited to the regression model obtained using the ordered logistic regression approach. There are two main reasons for doing so. Firstly, the joint working party from the RCP and BGS (1992) recommended that the total Barthel Index should be categorised for clinical use and the OLR procedure is the most appropriate method of analysing this type of data.

Secondly the models obtained with the OLR and SMR approaches were very similar so there would be some duplication if the results from both were to be discussed.

Most of the literature reporting the predictive factors for dependency six to 12 months after a hip fracture is based on studies that have restricted themselves to community-residing patients or have used series of patients that have been selected in other ways.

Only three studies have been published using an unselected series of patients. The studies by Baker et al (1979) and Keene et al (1993) are of limited value as they assessed a limited range of predictor variables in relation to dependency and employed univariate analyses only. The study by Jette et al (1987) was however more comprehensive and will form the basis for the discussion in this section.

Jette et al (1987) noted a significant multivariate relationship between increasing age and functional state at six months post-fracture but this did not hold at one year post-fracture. The study was conducted using 75 rehabilitation patients and was designed to investigate the role of intensive rehabilitation on functional recovery. In the current study age managed to achieve multivariate significance at one year post-fracture. The lack of predictiveness of gender noted by Jette et al (1987) was confirmed by the present study. Jette et al (1987) noted that discharge to a nursing home or rehabilitation hospital was independently predictive of a poorer functional outcome at one year post-fracture. The current study showed that a more dependent form of pre-fracture accommodation was also independently predictive of increased dependency. Co-morbidity was shown not to be predictive of dependency at a multivariate level in the study by Jette et al (1987) and the present study. Impaired cognition was shown to be predictive of increased dependency at one year post-fracture in the current study and at a univariate level by Baker et al (1979) whilst Jette et al (1987) did not find a significant association between pre-fracture emotional state and subsequent functioning. Poor pre-fracture physical functioning was reported by Jette et al (1987) as being predictive of future impaired functioning at a multivariate level. The role of dependency in the current study was amply confirmed by the entry of 'how the patient managed on a daily basis', the total Barthel score, the Clackmannan self-care subscale

and the 'maximum supported walking distance' into the model. Keene et al (1993) found a significant univariate relationship between sustaining an extracapsular fracture and poorer mobility at one year post-fracture as did the present study. However an independent predictive effect of fracture type on dependency was not found in the present study nor in the study by Jette et al (1987).

In summary, the importance of variables denoting pre-fracture dependency and mobility in predicting future dependency was evident with four variables attaining independent significance in the current study and confirms the limited literature reporting on a comparable unselected series of patients. The predictive role of age and pre-fracture accommodation have not previously been reported at a multivariate level. Excellent prediction was obtained with the ordered logistic regression model as indicated by the AUC for the serial ROC curves ranging from 0.86 to 0.95.

### **6.5.3 Comparison of Models for Self-reporting Group and the Whole Study Population**

A greater number of significant univariate associations were found with the whole study population than with the self-reporting group. This was due to the greater heterogeneity within the whole study population and the larger number of individuals which increased the power of the statistical analyses. There were 187 patients in the whole study analysis compared to only 124 patients for the SRG analysis.

The baseline variables which attained significance in the whole study population but not the self-reporting group reflected the greater dependency of the informant requiring individuals. These variables were accommodation, total AMT score, 'how the patient managed on a daily basis', the total Barthel score and the Clackmannan self-care subscore. These were in addition to age and the maximum supported walking distance which were common to the models for both the SRG and the whole study population. It was interesting to note that the Clackmannan self-care subscore came into the model as a second line variable even though the total Barthel score, which incorporates a self-care subscore, was already in the model. The Barthel self-

care subscale concentrates on the more fundamental self-care skills with three of the seven questions concerning toileting capabilities whilst the Clackmannan self-care subscale does not cover this dimension. Bearing this in mind it was very interesting that the Barthel self-care subscale managed to reach independent significance for the SRG which had a large proportion of high functioning individuals prior to their fracture. The type of inside walking aid entered the regression model for the SRG of patients but not for the whole study as it was strongly confounded by the total Barthel score. Fracture type, which was the other variable to enter the OLR model for the SRG, was noted to be confounded by study status in the whole study group analysis and failed to achieve multivariate significance.

In summary, the significant independent predictor variables obtained for twelve month dependency in the whole study population compared to the SRG of patients indicated the greater frailty of the IRG of patients. Slightly better predictive capacity for the ordered logistic regression models for the whole study population compared to the SRG of patients was obtained due to the greater heterogeneity in the former.

## **6.6 TWELVE MONTH HIP FUNCTION**

Hip function in the EHFS was measured with the Harris Scale. This scale has pain, mobility, activities of daily living, hip deformity and range of movement components with their respective weightings being 44%, 33%, 14%, 4% and 5%. Hip pain was considered to be an important outcome measure in its own right and an additional multivariate analysis was performed to determine its independent predictors and this is presented in section 6.7. The Harris Scale scores range from 0 to 100 with a higher score indicating better hip function.

A total of 20 patients were not included in the analysis. Four patients who sustained severe medical events during their year of follow-up were excluded. Additional exclusions were for the following reasons : five patients had migrated and were followed up by postal questionnaire; three patients with severe dementia were not co-operative; one patient who was sub-normal would not co-operate; one patient with a



personality disorder would not co-operate; one patient had a marked painful sensory dysaesthesia secondary to a cerebrovascular accident involving the leg on which his hip fracture had occurred; one patient had severe diabetic ulcers on her limbs precluding examination; one patient had severe COAD; one patient was a bilateral amputee; one patient refused the 12 month interview; and the data for one patient was missing. The distribution of Harris scores is given in Figure 4.34.

### **6.6.1 Univariate Analysis**

Selected univariate analyses are given in Appendix 12. Surprisingly there was not a significant correlation between age and 12 month hip functioning. Patients who were self-reporting or from less dependent forms of accommodation had significantly greater hip scores as did patients with better baseline physical and mental health. It was interesting to note that a previous hip fracture did not influence the Harris score at one year after the most recent fracture.

### **6.6.2 Multivariate Analysis**

The multivariate analysis was performed using two approaches. Firstly, the Harris score was categorised according to criteria recommended by Harris in his seminal paper in 1969. In the second analysis the Harris score was analysed as a continuous variable.

#### **6.6.2.1 Selection of First Line Variables**

In the orthopaedic literature descriptive studies have been published reviewing hip function in selected series of patients to evaluate the outcome of a particular surgical procedure. None of the other more general studies reviewing the outcome from a hip fracture have systematically used a scale to look at hip function per se. Most have reported hip function indirectly in terms of mobility and ability to perform the primary and instrumental activities of daily living. The Harris scale has 47% of its score comprised of mobility and activities of daily living components. Mossey et al (1989) derived a physical functioning variable using a principal components analysis based on activities of daily living and the assistance required to walk or travel distances. This



composite variable is in fact the outcome variable which corresponds most closely to the physical functioning component of the Harris score reported in the literature. Mossey et al (1989) looked at a broad range of potential predictors including age, mental state, general health and physical functioning. Their results help guide the selection of baseline variables for prediction of hip functioning at 12 months post-fracture in the current study. Variables directly related to the hip account for 53% of the Harris score with pain, deformity and range of movement contributing 44%, 4% and 5% respectively. As a direct result of the large contribution of pain to the total Harris score the potential predictors for hip pain, which were discussed earlier, also guided the selection of variables for hip functioning in the present study.

The selection of the first line variables for predicting hip function was largely based on the predictors selected for hip pain and the 12 month physical functioning variable derived by Mossey et al (1989). In addition to this, the predictors selected for dependency at 12 months in the current study, as gauged by the total Barthel score, were also considered as this outcome variable covers the primary activities of daily living. The variables age, sex, study status, fracture type, general health, total AMT score, how the patient managed on a daily basis and inside walking aid were selected. The Barthel mobility subscore, maximum walking distance, and limitations in mobility prior to the fracture were also selected to predict hip function one year post-fracture for self-evident reasons.

### **6.6.2.2 Ordered Logistic Regression**

Harris (1969) used a five category scale for grading the results from his hip score for clinical use. A score of more than ninety was graded excellent, eighty to ninety good, seventy to eighty fair, and below seventy poor. This classification was used for the ordered logistic regression. See Figure 4.34 for distribution of scores.

#### **6.6.2.2.1 First Line Variables in Regression Model**

Three of the first line variables, namely the maximum supported walking distance, the total number of categorised medical conditions and the fracture type, entered the

**Table 6.16** Twelve month hip function ordered logistic regression analysis**A. FIRST LINE PREDICTOR VARIABLES****1. Forward stepwise regression****a) Significant variables**

Variable	Coefficient	Standard error	P
Intercept 1	-1.46	0.72	-
Intercept 2	0.79	0.71	-
Intercept 3	2.36	0.76	-
Maximum supported walking distance	-0.45	0.10	0.0001
Total number of categorised medical conditions	0.52	0.14	0.0002
Fracture type	0.77	0.31	0.013

**b) Non-significant variables**

Variable	P
Age	0.50
Sex	0.16
General health	0.21
Managed on a daily basis	0.64
Inside walking aid	0.35
Limitation in mobility	0.43
Barthel mobility subscale score	0.37
Total AMT score	0.88
Study status	0.17

**2. Backward stepwise regression**

Same regression model generated as from forward procedure.

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-1.53	0.71	-
Intercept 2	0.74	0.71	-
Intercept 3	2.30	0.75	-
Maximum supported walking distance	-0.43	0.10	0.0001
Total number of categorised medical conditions	0.50	0.13	0.0002
Fracture type	0.80	0.31	0.0095

regression model at the 10% level of significance. Patients who sustained an intracapsular fracture, had fewer medical problems or were able to walk greater distances prior to their fracture were significantly more likely to have better hip function at 12 months post-fracture. Refer to Table 6.16 for details of the regression model.

Performing a backward stepwise procedure yielded the same regression model as the forward stepwise approach indicating that the model was robust.

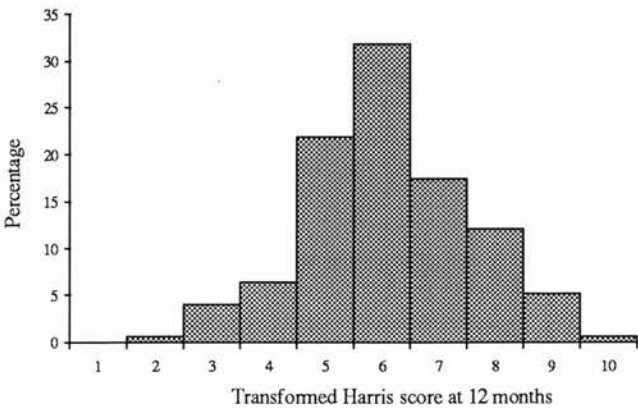
**6.6.2.2.2      Final Regression Model**

None of the second or third line variables attained the necessary 5% or 1% levels of significance required respectively for entry into the model. The final regression model was therefore the model obtained after entering the first line variables.

A patient who sustained an extracapsular fracture had an odds ratio of 2.23 of moving into a more dependent hip functioning category compared to a patient with an intracapsular fracture. For each additional categorised medical condition the odds ratio of moving into a worse hip functioning category was 1.65. On the other hand every increment in the six point walking distance scale was associated with a 0.65 odds ratio of being in a poorer hip functioning category.

**6.6.2.3      Multiple Regression**

The raw values for the Harris score were noted to be non-normally distributed. The transformation which minimised the skewness was the square root of (100 - total 12 month Harris score) and this variable was used for the multiple regression analysis. See Figure 6.15.



**Figure 6.15** 12 month transformed Harris Scale scores

**6.6.2.3.1**      First Line Variables in the Regression Model

The maximum walking distance was the first baseline variable to be entered into the multiple regression model, followed by the total number of categorised medical conditions, fracture type and study status. Informant requiring patients who sustained an intracapsular fracture, had fewer medical problems and had better walking ability prior to their fracture were significantly more likely to have better hip function, as assessed by the Harris score, at one year post-fracture. Refer to Table 6.17. The baseline variables which failed to attain independent significance are also given in Table 6.17.

**Table 6.17** Twelve month hip function multiple regression analysis

**A.      FIRST LINE PREDICTOR VARIABLES**

**1.      Forward stepwise regression**

**a)      Significant variables**

Variable	Coefficient	Standard error	P
Intercept	4.28	0.51	-
Maximum walking distance	-0.28	0.063	0.0001
Total number of categorised medical conditions	-0.34	0.084	0.0001
Fracture type	0.65	0.19	0.0011
Study status	0.48	0.23	0.042

**b)      Non-significant variables**

Variable	P
Age	0.85
Sex	0.17
General health	0.41
Managed on a daily basis	0.34
Inside walking aid	0.99
Limitation in mobility	0.47
Barthel mobility subscale score	0.76
Total AMT score	0.18

**2.      Backward stepwise regression**

Same regression model generated as from forward procedure

**Table 6.17 (continued)** Twelve month hip function multiple regression analysis

**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept	4.25	0.50	-
Maximum walking distance	-0.28	0.063	0.0001
Total number of categorised medical conditions	-0.34	0.084	0.0001
Fracture type	0.66	0.19	0.0008
Study status	0.49	0.23	0.036

The robustness of the model was verified when the backward stepwise procedure produced the same model using the first line variables.

**6.6.2.3.2 Final Regression Model**

No second or third line variables met the 5% and 1% levels of significance required respectively for inclusion into the final regression model. The final regression model is therefore the same model as presented in Table 6.17.

Cumulatively the maximum walking distance, total number of categorised medical conditions, fracture type and study status explained 26% of the total variance of the Harris score. This corresponds to a multiple correlation coefficient of 0.51. Individually the maximum walking distance, the total number of categorised medical conditions, fracture type and study status contributed 14%, 6%, 4% and 2% respectively in the stepwise procedure.

**6.6.2.4 Comparison of Regression Models**

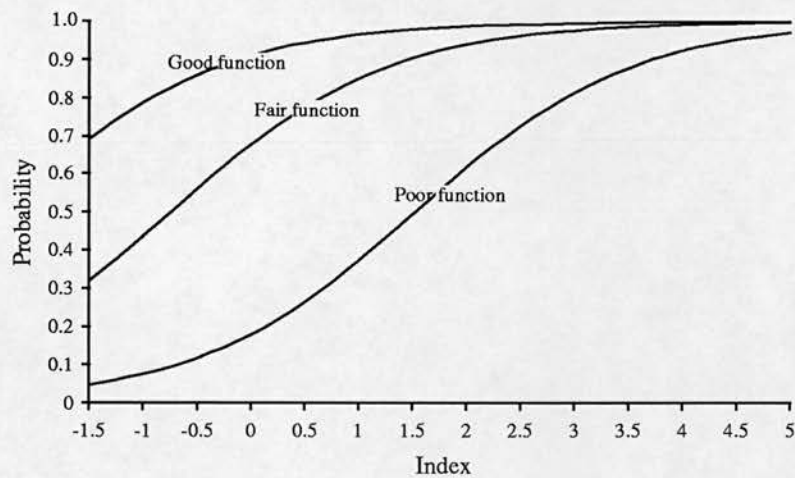
Very similar regression models were obtained using the two different statistical approaches. Fracture type, the total number of categorised medical conditions and the maximum supported walking distance were common to both models. The multiple regression model also found that study status was predictive. The entry of this additional term would be due to the fact that the multiple regression analysis used



the actual value of the hip function score thereby giving it greater power to detect a significant relationship if one did exist.

6.6.3 Prediction in Practice

A self-reporting patient with no categorised medical conditions who could walk up to one mile prior to their intracapsular fracture can be calculated to have an index value of -0.92. Referring to Figure 6.16 it can be seen that such a patient will have a



probability of 0.08 of having poor hip function at one year post-fracture. The probability of fair or poor function is 0.46 and the probability of function that is not excellent is 0.80.

Figure 6.16 12 month hip function sigmoid curves

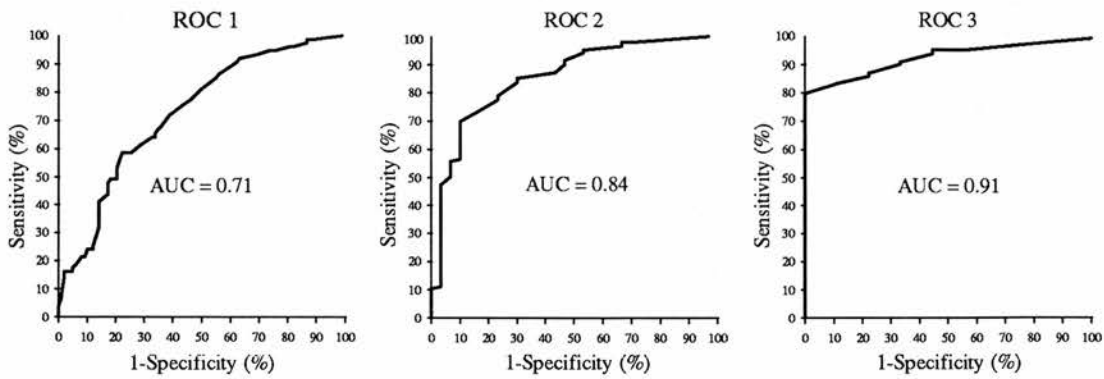
Referring to Table 6.18 an index value in the range -1.50 to -0.51 corresponds to probabilities of 0.08, 0.23 and 0.62 for poor hip function, fair or poor function, and function less than excellent respectively.

Spearman's correlation coefficient of -0.49 suggested a moderate association between the observed and the expected hip function categories.

Table 6.18 Prognostic index values cross-tabulated against observed 12 month hip function

Index	Observed frequency for hip function				Total
	Poor	Fair	Good	Excellent	
-1.50-<-0.51	1	2	5	5	13
-0.50-<-0.01	3	6	4	2	15
0.00-<0.49	6	12	5	2	25
0.50-<0.99	14	16	4	0	34
1.00-<1.49	11	13	2	0	26
1.50-<1.99	12	6	0	0	18
2.00-<2.49	12	6	0	0	18
2.50-<4.99	16	7	1	0	24

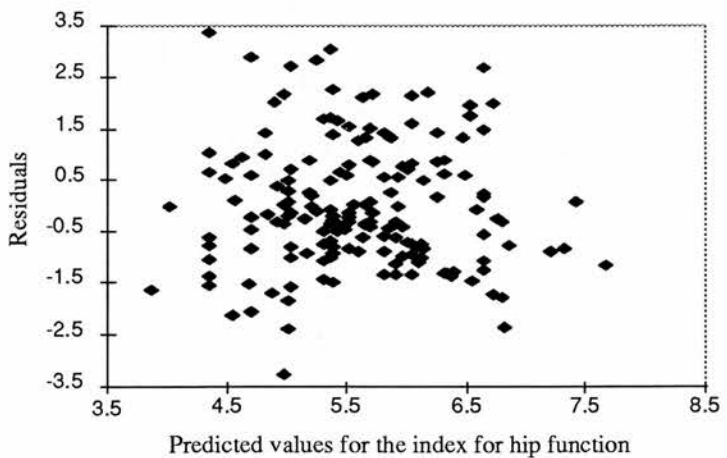
Reasonable predictive capacity for hip function at 12 months was obtained with the logistic regression model as indicated by the AUC for the serial ROC curves ranging from 0.71 to 0.91. See Figure 6.17. Poorest prediction was obtained for poor



**Figure 6.17** 12 month hip function serial ROC curves

function versus fair or better function. An 80% chance of correctly identifying poor function was associated with a 52% chance of correctly identifying fair or better function. The best prediction was obtained for good or a lesser degree of functioning versus excellent functioning. An 80% sensitivity corresponded to a 100% specificity.

Figure 6.18 indicates that the transformation of the Harris score used for the multiple regression model resulted in the assumptions of the regression model being met as there is no evidence the residuals were dependent on the predicted values and there were no gross outliers.



**Figure 6.18** Residual plot for predicted values of index for 12 month hip function

#### 6.6.4 Discussion

The Harris Scale is a composite scale comprised of hip pain, walking ability, activities of daily living that reflect mobility, hip deformity and range of movement as mentioned earlier. There are no comparable studies in the literature reporting the predictors of hip function using a scale which incorporates all of the above dimensions. As a result of this the discussion will compare the results of the current study with the results of studies which have looked at a more limited range of hip function outcome. The predictors for hip pain, which constitutes 44% of the Harris score, will be described in section 6.7.2.3. The predictors for the physical functioning variable from the study by Mossey et al (1989) will be presented first as this variable is the closest to the non hip pain component of the Harris score reported in the literature. After this the predictors for the individual constituents of the non hip pain component of the Harris score in the literature will be discussed briefly.

In the literature the closest outcome variable to the non hip pain component of the Harris scale is the physical function variable used by Mossey et al (1989), as just mentioned, and it was described in section 6.6.2.1. At a univariate level of analysis Mossey et al (1989) found age, self-rated health, number of medical conditions, mental state, primary and instrumental activities of daily living, walking ability and pre-fracture physical functioning all attained significance in their community-residing population. Of these variables only age and mental state reached multivariate significance. In the current study an unselected population was investigated and broadly comparable significant univariate relationships were obtained to that of Mossey et al (1989) with the inclusion of additional variables reflecting general frailty such as study status and pre-fracture accommodation for example. The independent predictors in the present study that were identified for 12 month hip function were study status, fracture type, the total number of medical conditions and the maximum supported walking distance. The fact that age appeared in the model for Mossey et al (1989) but not in the current study possibly indicates the greater importance of physiological age compared to chronological age in the present study. This hypothesis was supported by the fact that the total number of categorised medical

conditions was the most important independent predictor in the present study. Cognitive state, the other independent predictor identified by Mossey et al (1989) also did not attain independence in the current study. However the variable study status may be viewed as a proxy for mental state as the main reason for institutionalisation in the present study population was dementia. It was not surprising that the baseline maximum walking distance attained independent significance as it gives a good indication of hip function. A further contributory factor would have been the fact that walking distance comprises 11% of the total Harris score. The greater heterogeneity of the patients in the current study facilitated the identification of predictors relative to the study by Mossey et al (1989).

Comparisons of the predictors obtained for the individual constituents of the non hip pain components of the Harris score for the current study with the literature will now be made although it is recognised that it is of limited usefulness. Walking ability in terms of gait, type of support required and distance walked constituted the second biggest component of the Harris score after hip pain accounting for 33%. Magaziner et al (1990) reported specifically on whether their unselected population had regained their pre-fracture level of mobility 12 months after their hip fracture. The information was simply recorded in terms of whether the level of assistance required for walking was the same or less than that prior to the fracture or greater. They found that advanced age and dementia were independently predictive of a poorer walking ability. In the current study age did not attain multivariate significance with hip function but study status, which is largely a reflection of the patient's cognitive status, reached significance. Katz et al (1967) using a series of rehabilitation patients noted that an older age, concomitant illness and pre-fracture disability were all univariately significantly related increased dependency on walking aids following a hip fracture. Keene et al (1993) noted in their unselected series of patients that an intracapsular fracture was significantly associated with better mobility at a univariate level in terms of the support required to walk both inside and outside the house as well as to do shopping at one year post-fracture. In the current study an intracapsular hip fracture was associated with better hip function as was greater pre-fracture walking distances.



Activities of daily living comprise 14% of the total Harris score. The four activities that are included all assess mobility. These activities are the ability to put on socks and shoes, sit, climb stairs and enter public transport. It should be noted that the ability to put on socks and shoes is classified as a self-care variable in the activities of daily living scales but there is an obvious mobility component to it with hip function being particularly important. Due to the fact that the self-care activities of daily living are not incorporated into the Harris scale, apart from the ability to put on shoes and socks, direct comparison with studies that include these activities is not possible. In the present study the activities of daily living were assessed using the Barthel Index of which self-care variables account for 60% of the total score. It was not surprising therefore that there was little overlap for the predictors of 12 month hip function and the total Barthel score in the current study, especially given the fact that the activities of daily living only comprised 14% of the total Harris score in the first place. The only variable that they had in common was the maximum supported walking distance which reflects the contribution of the mobility components to each of their total scores. Refer back to section 6.5.2 for further details on the predictors for the activities of daily living.

The four predictor variables that were identified in the current study for hip functioning explained 26% of the variance of the total Harris score. This represents a multiple correlation coefficient of 0.51 indicating that the prediction of hip function was reasonably accurate. Correlations were performed to assess the association between the different components of the Harris Scale. Interestingly it was observed that hip pain failed to have significant associations with all of the walking, daily activity, and deformity variables indicating that the internal consistency of the scale was not high. As indicated in section 2.6.9. the Harris Scale has never undergone any psychometric testing.

In summary, reasonable prediction of hip function at 12 months post-fracture was obtained with the regression model as indicated by the fact that a multiple correlation coefficient of 0.51 was obtained. The ROC curves also indicated a reasonable



predictive capacity of the regression models using different cut-off points for the Harris score, with the AUC ranging from 0.71 to 0.91. Direct comparison of the predictors for hip functioning obtained in the current study with the literature was not possible due to the different methods used for assessing hip function.

## **6.7 TWELVE MONTH HIP PAIN**

Hip pain is an important outcome following a hip fracture. The Harris Scale which was used in the EHFS to assess hip function has as one of its components a hip pain question as indicated in section 6.6. Hip pain is classified as an ordered categorical variable and there are six categories. The scores range from 0 indicating very severe pain to 44 indicating very minimal or no pain. Refer to Appendix 2 for further details and Figure 4.35 for the hip pain subscore distribution at 12 months post-fracture.

The four patients who sustained severe medical events during the course of follow-up were excluded from the analyses. Additionally one patient refused follow-up and the data for one patient was missing. The data for 187 patients were available for analysis.

### **6.7.1 Univariate Analysis**

Selected univariate analyses are presented in Appendix 12. None of the demographic variables apart from study status attained a statistically significant association with 12 month hip pain at the univariate level. Fracture type also failed to achieve univariate significance. The only general health variable to reach statistical significance was hearing. The total AMT score attained significance as did the total Barthel score and its self-care and mobility components. None of the other variables reflecting dependency were significant apart from the Clackmannan self-care subscale. Of the mobility parameters only the type of outside walking aid required, and the average and maximum supported walking distances reached significance. The direction of these associations indicated that the more impaired the mobility at baseline the lower the likelihood of the patient having hip pain at 12 months post-fracture. None of the social variables attained significance with hip pain at 12 months post-fracture.

## **6.7.2 Multivariate Analysis**

An ordered logistic regression analysis was performed given the ordered categorical nature of the pain variable.

### **6.7.2.1 Selection of First Line Variables**

A limited literature exists for the predictors of pain following a hip fracture. Mossey et al (1989) examined a broad spectrum of potential predictors for hip pain which they classified as : none, intermittent and constant. Keene et al (1993) simply reported a univariate association between fracture type and hip pain which was classified in a similar manner to pain in the Harris scale. The selection of potential first line predictors was consequently largely guided by the results from the study by Mossey et al (1989). Baseline variables investigated by Mossey et al (1989) included : age, pre-fracture place of residence, type of fracture, self-rated health, number of medical conditions, cognitive status, and physical functioning. All of these variables were used in the current study. Specific mobility variables that were incorporated into the current analysis were : inside walking aid, Barthel mobility subscale score, maximum walking distance, and a variable representing the number of limitations in mobility. Mossey et al (1989) restricted themselves to a female population who were resident in the community. As a result sex and study status were added to the list of potential first line predictors in the current study as well as the general dependency measure 'how the patient managed on a daily basis' in order to assess their predictive role.

### **6.7.2.2 First Line Variables in the Regression Model**

Six first line variables entered the ordered logistic regression model at the 10% level of significance. In order of entry these were : study status, fracture type, sex, Barthel mobility subscale score, total number of categorised medical conditions and age. Patients who were younger, female and self-reporting, sustained an extracapsular fracture, had more categorised medical conditions and were more mobile prior to their fracture were significantly more likely to be in a worse pain category at 12 months post-fracture. Refer to Table 6.19 for the regression model.

When a backward stepwise procedure was performed the same regression model was generated as for the forward stepwise procedure indicating that the model was robust.

**6.7.2.2.2      Final Regression Model**

Adding in the second and third line baseline variables did not result in the inclusion of any more terms into the regression model at the 5% and 1% levels of significance respectively. The final regression model is given in Table 6.19.

**Table 6.19** Twelve month hip pain ordered logistic regression analysis

**A.      FIRST LINE PREDICTOR VARIABLES**

**1.      Forward stepwise regression**

<b>a)      Significant variables</b>			
Variable	Coefficient	Standard error	P
Intercept 1	-5.82	2.30	-
Intercept 2	-2.98	2.08	-
Intercept 3	-2.14	2.07	-
Intercept 4	-1.59	2.07	-
Intercept 5	-0.54	2.07	-
Study status	1.07	0.38	0.0050
Fracture type	0.73	0.30	0.017
Sex	-1.21	0.44	0.0063
Barthel mobility subscale score	0.29	0.14	0.035
Total number of categorised medical conditions	0.29	0.13	0.024
Age	-0.037	0.020	0.056

<b>b)      Non-significant variables</b>	
Variable	P
General health	0.25
Managed on a daily basis	0.95
Inside walking aid	0.80
Maximum walking distance	0.81
Limitations in mobility	0.26
Total AMT score	0.98

**2.      Backward stepwise regression**

Same regression model generated as from forward procedure.

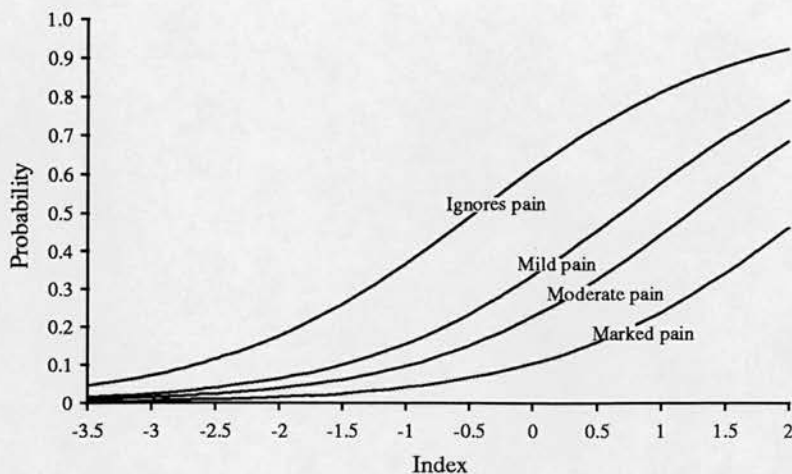
**Table 6.19 (continued)** Twelve month hip pain ordered logistic regression analysis**B. FINAL MODEL**

Variable	Coefficient	Standard error	P
Intercept 1	-5.82	2.30	-
Intercept 2	-2.98	2.08	-
Intercept 3	-2.14	2.07	-
Intercept 4	-1.59	2.07	-
Intercept 5	-0.54	2.07	-
Study status	1.07	0.38	0.0050
Fracture type	0.73	0.30	0.017
Sex	-1.21	0.44	0.0063
Barthel mobility subscale score	0.29	0.14	0.035
Total number of categorised medical conditions	0.29	0.13	0.024
Age	-0.037	0.020	0.056

Each decade increase in age was associated with an odds ratio of 0.67 of moving into a worse pain category whilst men had a 70% reduction in their odds ratio compared to women. A patient who was self-reporting had an odds ratio of 2.91 of moving into a worse pain category relative to informant requiring patients. The corresponding figure for an extracapsular fracture compared to an intracapsular fracture was 2.07. A single increment in the total number of categorised medical conditions or in the Barthel mobility subscale score were both associated with increased odds ratio of 1.34.

### 6.7.3 Prediction in Practice

An 80 year old female who suffered from angina, chronic obstructive airways disease as well as arthritis, and scored seven points on the Barthel mobility subscale prior to her extracapsular fracture can be calculated to have an index value of 1.26 using the ordered logistic regression model. When this is plotted on Figure 6.19 it can be seen that the probability of the patient having marked pain at 12 months post-fracture is 0.26, of moderate or marked pain 0.48, of mild pain or more severe pain of 0.60, or any degree of pain is 0.80.



**Figure 6.19** 12 month hip pain sigmoid curves

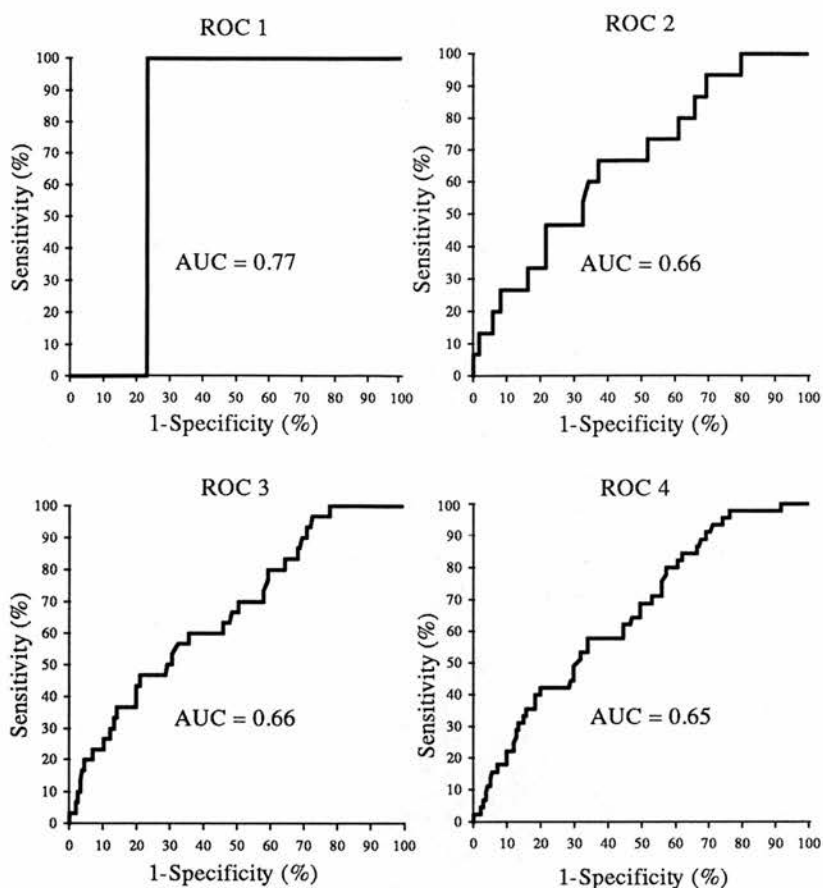
four pain categories outlined earlier are for a patient with an index value in the range 1.00 to less than 1.50 are 0.00, 0.097, 0.19, 0.32, and 0.68 respectively. Spearman's correlation coefficient for the correlation between the predicted and observed pain categories was -0.37 reflecting only a slight correlation.

**Table 6.20** Prognostic index values cross-tabulated against observed 12 month hip pain

Index	Observed frequency for hip pain						Total
	Disabled	Marked	Moderate	Mild	Slight	None	
-3.00-<-1.51	0	0	0	1	0	7	8
-1.50-<-1.01	0	0	0	0	2	8	10
-1.00-<-0.51	0	0	0	1	2	18	21
-0.50-<-0.01	1	2	1	2	2	18	26
0.00-<0.49	0	4	6	3	11	18	42
0.50-<0.99	0	1	2	3	9	25	40
1.00-<1.49	0	3	3	4	11	10	31
1.50-<2.99	0	4	3	1	1	0	9

The predictive capacity of the ordered logistic regression model was not high as can be seen from the AUC for the serial ROC curves presented in Figure 6.20. Poorest prediction was obtained for no pain versus any degree of pain as shown in ROC curve 4. An 80% chance of correctly some pain was associated with only a 43% chance of correctly predicting no pain. The best prediction was obtained for marked pain versus any lesser degree of pain. Here an 80% chance of correctly predicting marked pain was associated with a 77% chance of correctly predicting a lesser degree of pain.





**Figure 6.20** 12 month hip pain serial ROC curves

#### 6.7.4 Discussion

The univariate and multivariate results obtained by Mossey et al (1989) and the current study were not comparable. This must in part be attributable to the different study populations investigated. Mossey et al (1989) used a series of high functioning individuals who were resident in their own homes prior to their fracture whilst the present study analysed an unselected series of patients. The self-reporting group of patients in the current study were more directly comparable to Mossey et al's population.

In the present study a younger age was found to be independently predictive of more hip pain at 12 months which contrasts with the finding of Mossey et al (1989).

Younger patients may perhaps be less accepting of pain than more elderly patients. Women were also found to be significantly more likely to report pain than men in the present study. Patients who were self-reporting also had higher pain scores than individuals who required an informant. Differences in reporting practices may account for the independent effect of study status in predicting more pain 12 months after a hip fracture. Self-rated or informant-rated general health was not found to be predictive of hip pain in either the current study or in the study by Mossey et al (1989). Patients with more medical conditions however were found to be significantly more likely to report more severe hip pain. Better mobility at baseline as indicated by the Barthel mobility subscore was not surprisingly a predictor of greater pain on the grounds that these patients could be expected to be more active at 12 months post-fracture and therefore be more likely to experience hip pain. An extracapsular fracture was found to be predictive of greater pain at 12 months post-fracture in the current study and this contrasts with the univariate results of Keene et al (1993), who also used an unselected series of patients.

Study status was the most important independent predictive variable for hip pain as evidenced by the fact that it was the first term to enter the ordered logistic regression model. This may in part reflect differences in reporting practices. Once study status was in the model appreciable changes in the coefficients for the other terms occurred with this being most evident for the total number of categorised medical conditions. Due to the large effect of study status in this analysis the ordered logistic regression analysis was repeated for the SRG only. Rather surprisingly an identical set of predictors were obtained without study status of course.

There was considerable overlap between the predictors derived for hip functioning and hip pain as would be expected given that almost half of the total Harris score is due to the hip pain component. The baseline variables study status, fracture type and the total number of categorised medical conditions were common to both. The maximum supported walking distance also entered the regression model for hip

function whilst for hip pain the terms age, sex and Barthel mobility subscore reached significance.

In summary, patients who were younger, were self-reporting, had a greater number of medical conditions, were more active or who had sustained an extracapsular fracture were significantly more likely to experience greater hip pain. Only a weak association between the predicted and observed hip pain categories was however observed as indicated by a small value for the Spearman's correlation coefficient. Consistent with this was the relatively poor predictive capacity of the ordered logistic regression model as indicated by the low AUC for the majority of the ROC curves.

## **6.8 SUMMARY**

The independent predictors for mortality, accommodation, depression, dependency, hip function and hip pain at one year post hip fracture have been identified. Direct comparison of the predictors for the last four variables with the literature was necessarily limited due to a paucity of published material or the use of selected study populations which restricted the generalisability of their results. This was particularly a problem for hip function. In general, the results from the present study were in keeping with the literature and reflect the importance of mental and physical frailty in predicting outcome. As a result of a broad range of predictor variables and outcome variables being investigated in the current study it was not unexpected that a number of new predictors were identified.

The importance of general physical frailty in predicting mortality at one year was clearly established with the variables age, general health, the total number of categorised medical conditions, total Barthel score and the maximum supported walking distance all attaining independence, with the latter association being a new finding. Cognitive status however was not found to be predictive of mortality whilst fracture type was and both of these findings contrast with the majority of the literature. Cognitive status and fracture type were noted to confound each other in the multivariate analysis.

Twelve month accommodation was analysed in two ways in the current study. The first was to look at the actual accommodation at 12 months and the second was simply to see if the patient had moved to a more dependent form of accommodation. The results from the two analyses were very close. All five baseline predictors obtained from the change in accommodation analysis, namely age, baseline accommodation, cognitive state, the total GDS score and the total Barthel score also reached significance for the actual accommodation analysis although they were noted to be entered in a different order. Additionally 'how the patient managed on a daily basis' was found to be predictive of actual accommodation. A new predictor that was identified for twelve month accommodation was the total GDS score. The finding that neither the presence of co-residents or self-rated general health were predictive of accommodation at one year post-fracture seems counterintuitive but is in keeping with the majority of the literature.

Depression was assessed as both a binary variable, representing the presence or absence of depression, and as a continuous variable and the importance of psychological variables in prediction were made explicit. The total GDS score, the total PGCMS score and vision were common predictors to both analyses with the latter two being new findings. The variable representing religious beliefs also entered the analysis when the depression score was treated as a continuous variable and is attributable to the greater power of this analysis. The similarity of the sets of predictor variables obtained indicated that there is little information lost using the total GDS score as a binary variable. Additionally the significance levels of the independent predictors in both models were very similar further confirming the closeness of the two models.

Dependency was analysed for both the SRG of patients and the whole study population. Considerable overlap between the two sets of results was obtained reflecting the fact that the SRG group comprised two thirds of the whole study population. Age, the total Barthel self-care subscale, inside walking aid, the supported maximum walking distance and fracture type were determined to be

independent predictors. These variables mirror the fact that the Barthel Index is comprised of variables measuring self-care and mobility. The predictive role of fracture type is a new finding. The lack of predictiveness of cognitive and psychological state in the present study contrasts with the majority of the literature. To exemplify the differences in sets of predictors which could be obtained with different analysis strategies three types of analysis were performed for deriving the predictors for dependency for the whole study at 12 months post-fracture to assess their usefulness, but no clear cut advantage of one over the other emerged. The variables identified with the unstratified multiple regression analysis were : age, study status, total Barthel self-care subscale, Clackmannan self-care subscale and outside walking aid. The predictor variables obtained using a stratified multiple regression procedure were : sex, accommodation, study status, total AMT score, 'how the patient managed on a daily basis', total Barthel score and Clackmannan self-care subscale. The ordered logistic regression approach yielded the predictor variables : age, accommodation, total AMT score, 'how the patient managed on a daily basis', total Barthel score, the Clackmannan self-care subscale and the maximum supported walking distance. The predictor variables identified using the OLR analysis for the SRG of patients were age, accommodation, 'how the patient managed on a daily basis', the total Barthel score, the Clackmannan self-care subscale and the maximum supported walking distance. The first two of these variables have not been reported previously.

A review of the literature revealed that surprisingly little has been reported about the orthopaedic outcome of an unselected series of patients following a hip fracture using a standardised methodology. The independent predictors identified in the current study for hip function were study status, total number of categorised medical conditions, maximum walking distance and fracture type. Age and cognitive status were not found to be predictive and this contrasts with the limited literature. The predictor variables identified in the current study explained 26% of the variance of the Harris score, representing a multiple correlation coefficient of 0.51 indicating that the prediction of hip function was reasonably accurate. Considerable overlap was



obtained for the predictors of hip function and hip pain. This was not unexpected given that hip pain comprises 44% of the Harris score. In the current study age, sex, study status, the total number of categorised medical conditions, the Barthel mobility subscale score and fracture type were all found to be predictive of hip pain at one year post-fracture and all of these are new findings.

The predictive ability of the indices varied considerably for the various outcome measures. The regression model for hip pain had the weakest predictive capacity as indicated by the AUC of the serial ROC curves ranging from 0.65 to 0.77. This contrasts with the excellent predictive capacity obtained for the prediction of dependency at 12 months for the whole study population. For this outcome variable the seven AUC ranged from 0.86 to 0.95.

## **CHAPTER 7**

### **OVERVIEW**

#### **7.1 INTRODUCTION**

The purpose of this chapter is to present the main study findings, put them into context with the literature, and then discuss their implications as well as the further work that needs to be undertaken to address fully all of the aims of the Edinburgh Hip Fracture Study. The thesis has limited itself to addressing the first two aims of the EHFS due to pragmatic constraints on what is achievable in a three year research period and the maximum permitted thesis length. As a result, the overview will emphasise the epidemiological and statistical aspects of the EHFS, while touching on the wider clinical practice and Public Health Medicine issues which arise in relation to aims three and four of the EHFS. It will begin with a review of the study results. This will be followed by a critical review of the study methodology so that the adequacy of the study and hence the usefulness of its results can be assessed. Comparisons with the literature will then be made. The final part of the chapter will be devoted to discussing the application of the study findings to clinical practice and to Public Health Medicine before considering the future developments that are required to fulfil aims three and four of the EHFS.

#### **7.2 STUDY RESULTS**

In this section a brief overview of the descriptive results of EHFS will be presented. A very general outline of the multivariate results will then follow. More detailed comments about specific predictor and outcome variables will be given in section 7.4 where the EHFS results are put into context with the literature to avoid repetition.

Case ascertainment in the EHFS was determined to be over 99% complete after cross-checking against data supplied by hospital information systems and from the Information and Statistics Division of the Scottish Health Service.

### 7.2.1 Descriptive Results

The EHFS population was elderly and frail. The average age was 81 years (SD 8.1) with a 4:1 female predominance. 18% of the patients had their health rated as poor or very poor and 34% had significant mental impairment as gauged by the Abbreviated Mental Test. Only 56% could walk unaided inside prior to their fracture. 13% of the study population were categorised as being dependent using the Barthel Index, and just 28% of the patients were recorded as being able to manage on a daily basis without any difficulty. 58% of the patients lived in their own homes prior to their fracture and 40% of these individuals required a home help. The EHFS patients also had a restricted social network. For example, 44% of the patients had a visitor only once a week or less prior to their fracture.

Thirty nine percent of the patients in the EHFS required an informant to provide information on their behalf principally because of the presence of Alzheimer's Disease which impaired the quality of the information that they could provide. A nested proxy/patient validation study of the baseline data was performed to ascertain whether the information provided by the patients and their informants was comparable. The results indicated a generally close correlation between the two different sources of information. There was however a tendency for the patients to overstate their independence relative to their proxies and this is consistent with the literature.

A total of 60 patients were excluded from the EHFS. The majority were excluded on the basis that the hip fracture was probably not osteoporotic or because the patient was obviously moribund at the time of their fracture. The leading reasons for exclusion were : being less than 60 years of age (17); sustaining a pathological fracture (11); or being moribund (20). One patient was excluded because she refused to participate in the study.

The secular changes in the EHFS were reviewed in two ways. The survivor cohort was used to assess the impact of the hip fracture at the individual level as the distorting effect

of the frailer individuals dying was removed by adopting this approach. The whole study population was used to gauge the burden of hip fractures at the societal level.

A substantial mortality and morbidity was documented following the hip fracture over the year of follow-up. A cumulative mortality of 29% was observed. Little change in cognitive or psychological functioning was noted but a marked deterioration in physical functioning was seen. A general pattern of recovery emerged over the year following the fracture. At one month there was a profound impairment of functioning. Partial recovery then occurred over the next five months before plateauing out over the final six months of follow-up below the baseline level.

The mobility parameters most affected by the hip fracture were outside walking aid dependency and the distance able to be walked, the ability to climb stairs, and the ability to get out of a low chair. The decline in functioning was most marked for the last variable with 55% of patients being able to get out of a low chair without any difficulty prior to their fracture whilst only 15% could manage this at one year. The two main hip complications present at one year post-fracture were shortening of the femur and pain. 12% of the patients had more than one inch of shortening and only 55% had no pain. The decline in mobility noted earlier however was greater than would have been expected intuitively from these complications plus the effect of ageing over one year. Psychological problems which arose following the fracture may well have been a contributory factor and this has been documented recently by Tinetti et al (1994). The loss of confidence in walking directly attributable to a fear of falling again may have been particularly important.

Interestingly though, there was no change in the proportion of people who were housebound immediately prior to their fracture and one year later. The primary and instrumental daily activities most profoundly affected by the hip fracture were bathing and doing the heavy shopping, reflecting the importance of mobility in carrying out these activities.

The impact of the hip fracture at the societal level was also assessed in terms of the health and social services required in conjunction with the type of accommodation occupied. It

should be noted that the informal support provided by carers was not measured in this study and indeed has not been done in any other comparable study. Individuals who were still in the community at one year post-fracture were more dependent as reflected by their increased use of the health and social services. Despite this, the overall use of these services declined. This was due to the frailer individuals either moving into more dependent forms of care, where these services were no longer required, or dying. The number of people in the current study who were in supported forms of care had decreased slightly over the study period. This was due to the fact that even though surviving patients were moving into more dependent forms of care following their hip fracture this was offset to a greater extent by the frailer individuals who were in supported accommodation at the time of their fracture dying during the course of follow-up. The formal burden of hip fracture patients to society at one year post-fracture was consequently less than it had been at the time of their fracture.

### **7.2.2 Analytic Results**

Only the multivariate results will be reviewed in this section as the univariate findings are limited by the fact that confounding factors are not taken into account.

Age, physical and mental health variables, selected dependency and mobility parameters as well as fracture type emerged as being important predictive factors for outcome following a hip fracture at both one and 12 months post-fracture. The predictor variables are summarised in Tables 7.1 and 7.2. It was interesting to note that baseline depression, as gauged by the Geriatric Depression Scale, was only found to be predictive of accommodation at 12 months in addition to the anticipated prediction of future depression.

The only social variable which was found to have predictive value was whether the patient was living with someone. This was unsurprisingly predictive of placement at one month. Perhaps the difficulty in quantifying social variables accounted for their general lack of predictiveness.

Tables 7.1 and 7.2 also show that the significant baseline predictor variables for the SR group were grossly comparable to that obtained for the whole study population for any



Table 7.1 Baseline predictor variables for one month outcome variables

OUTCOME VARIABLE	STUDY POPULATION	STATISTICAL ANALYSIS	PREDICTOR VARIABLES
Mortality	Whole study	LR <sup>2</sup>	Age, managed on a daily basis, inside walking aid
Accommodation	SR group <sup>1</sup>	LR	Age, co-residents, AMT score, managed on a daily basis, Clackmannan self-care score, fracture type
Depression	SR group	LR	GDS score, whether anyone relied on patient for help, general health
	SR group	SMR <sup>3</sup>	GDS score, PGCMS score, whether anyone relied on the patient for help, frequency of church attendance, optimism about walking, general health, outside walking aid
Dependency	SR group	OLR <sup>4</sup>	Age, general health, managed on a daily basis, Barthel score, outside walking aid, fracture type
	Whole study	OLR	Study status, AMT score, general health, Barthel score, Clackmannan self-care score, main helper, outside walking aid, fracture type

Key :

- 1 Self-reporting group
- 2 Logistic regression

- 3 Stratified multiple regression
- 4 Ordered logistic regression

Table 7.2 Baseline predictor variables for 12 month outcome variables

OUTCOME VARIABLE	STUDY POPULATION	STATISTICAL ANALYSIS	PREDICTOR VARIABLES
Mortality	Whole study	LR <sup>2</sup>	Age, general health, total number of categorised medical conditions, maximum supported walking distance, fracture type
Accommodation	SR group <sup>1</sup>	LR	Age, accommodation, GDS score, AMT score, Barthel score
	SR group	OLR <sup>3</sup>	Age, accommodation, GDS score, AMT score, managed on a daily basis, Barthel score
Depression	SR group	LR	GDS score, PGCMS score, vision
	SR group	SMR <sup>4</sup>	GDS score, PGCMS score, religious conviction, vision
Dependency	SR group	OLR	Age, Barthel self-care score, inside walking aid, maximum supported walking distance, fracture type
	Whole study	OLR	Age, accommodation, AMT score, managed on a daily basis, Barthel score, Clackmannan self-care score, maximum supported walking distance
	Whole study	UMR <sup>5</sup>	Age, study status, Barthel self-care score, Clackmannan self-care score, outside walking aid, fracture type
	Whole study	SMR	Sex, accommodation, study status, AMT score, managed on a daily basis, Barthel score, Clackmannan self-care score
Hip pain	Whole study	OLR	Age, sex, study status, total number of categorised medical conditions, Barthel mobility sub-scale score, fracture type
Hip function	Whole study	OLR	Total number of categorised medical conditions, maximum walking distance, fracture type
	Whole study	SMR	Study status, total number of categorised medical conditions, maximum walking distance, fracture type

Key :

- 1 Self-reporting group
- 2 Logistic regression
- 3 Ordered logistic regression
- 4 Stratified multiple regression
- 5 Unstratified multiple regression

given outcome measure. This was expected because the SR group comprised 61% of the whole study population. However the greater overall frailty of the whole study population compared to the SRG was indicated by the greater number of dependency variables which entered the regression models for the whole study population.

It was also interesting to observe that only a limited number of predictor variables were identified as being significant for any outcome measure and that considerable overlap was noted between the predictors for the various outcome measures. Thirteen different variables were identified for the four one month outcome variables and 17 for the six 12 month outcome variables. Age, general health, 'how the patient managed on a daily basis', the total Barthel score and fracture type were the five baseline variables which attained multivariate significance the most frequently. These variables reflect the importance of patient frailty on subsequent outcome as well as the role of fracture type. For the one month outcome variables baseline general health, dependency and co-residents were more important for prediction than they were for the 12 month outcome variables. Baseline accommodation was noted to be a predictor for 12 month outcome but not for one month outcome.

The prognostic index with the highest predictive capacity, as indicated by the AUC of the ROC curve(s) generated for each regression model, was the model obtained for predicting 12 month dependency for the whole study population with the AUC ranging from 0.86 to 0.95. The poorest predictive capacity was obtained for accommodation and hip pain at 12 months with the ranges for their AUC being 0.63 to 0.79 and 0.65 to 0.77 respectively.

The descriptive and analytic results described in section 7.2 clearly indicate that aims one and two for the EHFS have been fulfilled. A detailed description of the baseline and follow-up characteristics of an elderly osteoporotic hip fracture population has been provided and the inter-relationships between outcome and the pre-fracture status have been closely assessed.

### 7.3 ADEQUACY OF THE STUDY METHODOLOGY

Much effort was expended at the design stage of the study in order to maximise the usefulness of the research. An extensive literature review was undertaken and experts in epidemiology, medical statistics, orthopaedics, geriatrics, and rehabilitative medicine were consulted at the initial stages.

Attention was directed at obtaining a representative sample of patients with osteoporotic hip fractures secondary to involutional osteoporosis. As nearly all patients with a hip fracture are treated operatively, acute hospitals were viewed as being the best source of potential study subjects. It was appreciated that a very small number of patients may have either been moribund at the time of their fracture and not admitted for definitive treatment, or died shortly after their fracture. There was no feasible way of identifying these patients.

The study exclusion criteria were compiled so that the population studied comprised individuals who had sustained an osteoporotic hip fracture, although definitive verification of this was not made. Bone mass density measurements were not possible for logistical reasons and indeed have never been incorporated into any comparable study. Patients who were obviously moribund were not enrolled into the study for ethical reasons. A total of 59 patients were excluded from the EHFS. The leading reasons for exclusion were outlined in section 7.2.1. 270 (98%) of the 275 eligible patients were entered into the study. Of the five patients who were eligible for the study but were not enrolled one patient refused to participate in the study, two were omitted in error on the basis of their place of residence and the other two patients were later detected on the computerised hospital admission system retrospectively.

In many of the hip fracture studies only community dwelling patients with a high level of cognitive functioning were recruited as this is the group of patients whose rehabilitative potential is the greatest. In the current study the self-reporting group of patients was comparable to many of the selected populations reported in the literature. In order to gain a broader perspective of outcome following a hip fracture, patients with cognitive impairment, or difficulties with communication, or those who lived in institutional care were also included in the present study. A proxy was recruited to overcome any problems

with the information provided by these patients. It was necessary to check the accuracy of the proxy-derived information and a nested proxy/patient validation study was incorporated into the study design to address this issue. It is the only hip fracture study reported in the literature to have done this.

The degree to which the results from the EHFS can be generalised is dependent on the population studied. The entry criteria for the EHFS population were selected in order to obtain as homogeneous group of patients as possible with respect to the underlying cause of the fracture so that the same predictive factors would apply to other hip fracture populations with similar age and sex characteristics. The aim was to select a group of patients whose fracture was secondary to involutional osteoporosis. To meet this aim, patients less than 60 years with an osteoporotic fracture were excluded as their osteoporosis is usually secondary to a medical condition, such as alcoholism. Patients were also excluded if there was evidence that their fracture occurred as a result of significant trauma, or there was an underlying pathological process, such as a secondary neoplastic deposit. More controversially, patients who were obviously moribund, or died within one week of their hospitalisation for the definitive management of their hip fracture were also excluded in the EHFS. This group comprised one third of the 59 exclusions for the EHFS. There were three reasons for excluding this group of patients. Firstly, it would not have been ethical to have included moribund patients in the study. Additionally, it would have been difficult to obtain data from these patients, so their relatives may have had to provide it on their behalf, and necessarily a more limited range of information sought. Also, from a practical viewpoint it could be argued that prediction of outcome is only relevant for patients who survive the post-operative phase. However, from an audit stance, it would be preferable to have data on all of the patients. As a result of excluding moribund patients, together with those that died within one week of admission, the EHFS results are too optimistic with respect to mortality. At a descriptive level, however, if one makes the assumption that all the moribund patients at the time of admission died within one month, then the mortality rate at that time is 17%, which is comparable to that observed in other series of similar hip fracture patients. In total only 59 patients were excluded out of the total of 334 patients who fractured their hips during the recruitment



period, clearly indicating that the vast majority of patients were included in the study. Overall the EHFS population is representative of all Edinburgh patients who sustain and survive a hip fracture secondary to involutional osteoporosis. The results should therefore be applicable to similar populations elsewhere in Britain, as well as to other westernised countries with predominantly Caucasian populations.

The generalisability of the results from the EHFS also depends on the representativeness of patient management in Edinburgh. Surgical management and post-operative care is fairly standard within most orthopaedic units in Britain. The rehabilitation process, on the other hand, is less uniform and may range from no special care on a general surgical unit to a well planned triaging system as is the case in Edinburgh. At the time the EHFS was being conducted the Early Supported Discharge Scheme was introduced, and this clearly had an impact on the number of patients who were returning directly home within one month of their surgery, as well as on other dimensions of outcome measured in the EHFS.

As a result of this, the generalisability of the percentage of patients in different forms of accommodation at one month post-fracture for example is uncertain. However, the ordering of the scores from prognostic indices should be robust and those patients with the most favourable outcome in one system should still do well in another system.

Preliminary sample size calculations had suggested that 250 patients would be adequate to detect relationships between pre- and post-fracture variables of prognostic significance. 270 patients were finally recruited into the study thereby surpassing this figure and also making it one of the largest studies in its area.

A series of standardised questionnaires were used for assessment, in conjunction with ad hoc questions, for both predictor and outcome variables. The selection of the research instruments was largely guided by the recommendations by the joint working party of the Royal College of Physicians and the British Geriatrics Society in 1992 on how to assess the elderly. It was decided to adopt all of the standardised scales that were recommended by the joint working party for the EHFS in anticipation of their use becoming widespread and hence increasing the applicability of the results of the study. Furthermore, there was

the hope that these scales may have been widely adopted to form the basis for a minimum data set with obvious implications for audit. It was however appreciated that other scales may have better psychometric properties and/or be better suited to assess certain aspects of outcome than those recommended by joint working party. For example, the Nottingham Health Profile would have been a suitable alternative for measuring the quality of life given that it has been widely used in the United Kingdom, and has been validated in the elderly (Hunt et al 1985). Another possible scale for this dimension of health is the SF-36 or SF-12 (Ware et al 1993). With the benefit of hindsight, the mental health scales recommended by the joint working party to assess depression and quality of life were not very sensitive to change in our study population and alternatives should now be considered. It should be borne in mind however, that the lack of sensitivity of the Geriatric Depression Scale and the Philadelphia Geriatric Center Morale Scale may have been due to the unavoidable fact that data relating to pre-fracture state was collected after the hip fracture had occurred, and that this may have affected patient responses. Further research is required to establish more fully the responsiveness of these scales in the elderly.

Unlike the other scales recommended by the joint working party the short form of the Geriatric Depression Scale had not undergone rigorous psychometric testing. As a result the analysis of this variable in the EHFS was not restricted to consideration of the patient being 'depressed' or 'not depressed', using the recommended cut-off point of 5, but the individual scores were also examined. Another instrument, the Harris Scale, which was incorporated into the study to assess hip function, similarly had not undergone adequate psychometric testing. At the time of the study design no hip assessment instrument had been evaluated in terms of its reliability and validity. The Harris Scale was selected because it was the most widely employed instrument. The Clackmannan Scale was also included in the current study because it had an instrumental activities of daily living sub-scale, and also because of the known ceiling effect with the Barthel Index. Three additional scales were employed in the EHFS namely the Katz Scale, the Edinburgh Rehabilitation Status Scale and the Patient Judgements of Hospital Quality Questionnaire but have not been reported in the thesis for logistical reasons. The first of these was

included for comparative purposes, the second for its rehabilitative focus and the final one because it covered the domain of patient satisfaction.

A broader range of outcome variables were investigated in the current study than in any of the other published hip fracture studies. Of particular note was the orthopaedic follow-up in the present study which had not been reported previously for an unselected series of hip fracture patients. Outcome was assessed at one, six and 12 months post-fracture for a number of variables in the current study. As a result of this the present study is more comprehensive than most of the studies to date.

To minimise any 'learning curve' effect in the use of the scales, experience with the use of the Harris Scale and with the Barthel Index were obtained under supervision prior to the pilot study. Only the author was involved with the data collection throughout the study. A notebook was kept of coding criteria throughout the study so that uniformity of coding was maintained as well as a record of decisions made about difficult cases.

Every effort was made to maximise data collection throughout the study. Five patients who migrated were followed up by postal questionnaire which necessitated a slight reduction in the information obtained. Three patients refused follow-up at six months post-fracture but only one of these patients declined to participate in the 12 month interview. There were a small number of patients who either declined to complete the psychological scales at one month or on whom hip examination was not possible at the six and 12 month interviews. Five patients had their mental state misclassified at their initial interview. They were given the benefit of the doubt due to the lack of a previous history of cognitive impairment but it became evident on subsequent follow-up that they suffered from Alzheimer's disease. Overall, data collection was over 99% complete for the study.

As mentioned earlier in this section on the choice of the psychological scales, an unavoidable problem with the baseline data collection was that it was performed after the fracture had been sustained. Although the patients were asked to provide information on their pre-fracture status the fracture experience may have altered some of their responses.

One study has managed to obtain prospective information on hip fracture patients. This study was a very large cohort study, involving 2806 patients, which was addressing the effects of ageing and hip fracture occurrence was one of many outcomes that were being recorded (Marottoli et al 1992). As the pre-fracture assessment was performed anywhere up to three years before the hip fracture occurred, with the mean time interval being six months, this study has its own problems.

One of the strengths of the current study is the statistical approach employed for the analysis. Most of the studies in the literature have reported univariate findings only. A small number have published multivariate results. Most of these studies have restricted themselves to a single outcome measure, limited themselves to analysing outcome at one particular point in time, and used relatively unsophisticated methods. Particularly noteworthy is the little work that has been published on short term outcome measures. In the present study a hierarchical approach to modelling was adopted and a broad range of outcome measures were analysed multivariately at one and 12 months post-fracture. It was appreciated that the predictor variables obtained for any given outcome measure would be influenced by the type of statistical method used. This was illustrated in the present study using dependency at one year post-fracture as the outcome measure of interest.

In summary, the present study was strong methodologically. An appropriate study design was used to address the aims of the study. A representative sample of patients with an osteoporotic hip fracture was obtained. This was achieved by enrolling a consecutive series of acute hospital patients using clear entry and exclusion criteria which were selected so that a minimal number of patients would be excluded whilst still retaining representativeness. An extremely high response rate was achieved. The power of the study was adequate as the number of patients recruited surpassed the sample size calculations performed prior to the start of the study. Valid and reliable measures were used and experience with the measures was obtained prior to the main study. Only one researcher was involved with the data collection and consistency of coding was made a priority. Excellent compliance was obtained and there was only one drop-out during the



course of the study. Data collection was over 99% complete. The statistical analysis was supervised by a very experienced medical statistician ensuring that appropriate analysis was undertaken.

#### **7.4 LITERATURE COMPARISON**

The findings of the present study in general confirm and expand upon what has previously been reported in the literature. Comparison of the results of the current study with other hip fracture studies was however hampered by the use of : selected study populations; varying methods of assessment; different time intervals for assessing patients; varying lengths of follow-up; and differing statistical techniques. The outcome measure reported most frequently in the literature for unselected series of patients is mortality. For selected series of patients mortality, accommodation and dependency are the most commonly reported outcome variables. There is no published material looking at depression at one month after a hip fracture and only one study has derived predictors for depression at one year post-fracture. In the literature, apart from the studies which have assessed outcome following a particular surgical technique, only three studies have reported hip pain. Only one of these studies addressed multivariate relationships. Furthermore, only one non-orthopaedic series has assessed hip function comprehensively following a hip fracture. In the light of the paucity of the research directed at a broad range of outcome measures in hip fracture patients it was not surprising that a number of new predictor variables for various dimensions of outcome were identified in the EHFS. In this section the descriptive results from the EHFS will be briefly outlined and compared with the literature. This will be followed by the analytic results for the EHFS with the emphasis on important differences with the literature and the new findings.

The EHFS confirmed that the hip fracture population was elderly and frail with a marked female predominance. Thirty seven percent of the EHFS population lived on their own which was comparable to another British study (Greatorex 1988) but was considerably lower than the 62% that has been reported in Sweden (Sernbo and Johnell 1993). Considerable levels of pre-fracture comorbidity, reduced mobility and increased dependency were documented in the present study as well as in all the other hip fracture



studies. Variations in prevalence levels of morbidity reported in the literature were largely attributable to differences in the study populations selected, diagnostic patterns, the intensity of case-finding and the type of assessment instruments used. A high cumulative mortality of 29% was noted in the EHFS. This is much higher than the 11% which would have been expected in a general population with a similar age and sex structure. Most of the excess mortality occurred in the first two months following the hip fracture and is consistent with the literature. Little change in the general health and mental health variables were observed in the EHFS which was in keeping with the limited literature. A marked decline in mobility and increased dependency has been universally recorded in all studies. The general pattern of marked impairment in function at one month post-fracture, partial improvement by six months and then a plateauing out of function over the next six months observed in the EHFS confirmed what has been previously reported. Self-care was noted to be less markedly affected by the hip fracture than the mobility parameters which in turn were less profoundly affected than the more demanding of the instrumental activities of daily living in the EHFS and this accords with the literature. The EHFS is the first study to report the deterioration in the ability to get out of both a high and low chair. It is also the first study to document the greater sensitivity of the Clackmannan scale compared to the Barthel Index in detecting disability in a hip fracture population.

Most of the prognostic studies in the literature have restricted themselves to selected hip fracture populations thereby limiting the generalisability of their results. Furthermore, most have only investigated a very limited range of outcome variables usually in the longer term following a hip fracture. In the EHFS a broad range of outcome variables were assessed in both the short and long term and as a consequence a considerable number of new predictor variables for selected outcome measures were identified. This was most evident for outcome at one month post-fracture as there is a general dearth of research that has been performed at this stage of the patients rehabilitation with survival and placement being notable exceptions. The new baseline predictors for each outcome measure in the EHFS will now be reviewed as well as the important differences in the predictor variables with the literature and any unexpected findings.

Relatively poor prediction was obtained for one month mortality in the EHFS because only 19 deaths had occurred by this stage which reduced the power of the study to detect significant associations. Also, as noted earlier, moribund patients were excluded. Only three baseline variables managed to attain multivariate significance at one month compared to six at 12 months post-fracture. Age was found to be the most important predictive factor for mortality at one and 12 months in the present study which is in agreement with the literature. Mental health however was not a significant predictor which contrasted with the main body of evidence. General health was not found to be predictive of mortality at one month post-fracture. This was surprising as it is counterintuitive and also because two baseline variables indicating physical health were independently predictive of mortality at one year post-fracture. One other hip fracture study however has also reported this finding. Dependency as gauged by 'how the patient managed on a daily basis' and the type of inside walking aid were new predictor variables found in the present study for one month mortality. Another mobility variable the 'maximum supported walking distance' was found to be predictive of 12 month mortality and is also a new finding. Social factors were not determined to be independent predictors of survival in the current study although the literature about general geriatric populations indicate that they are important.

Accommodation at one and 12 months post-fracture for the SRG of patients were both independently predicted by age, mental state and two dependency measures in the EHFS which is in keeping with the literature. It was not anticipated that cognitive state would enter both models given that the SRG of patients did not have significant cognitive impairment at the time of their fracture. It was surprising that general health was not predictive either in the short or long term following the hip fracture and the former contrasts with the literature. The analyses performed for short and long term accommodation in the EHFS were not strictly comparable. The analysis for one month accommodation was undertaken to determine the predictors of whether the patient had returned to community or not at this stage. The rationale for this was so that the baseline variables which might be of use for the selection of patients for the Early Supported Discharge Schemes, which were outlined in chapter 1, could be identified. Comparing the

predictors obtained for one and 12 months accommodation it was found that the rate of return to the community at one month was additionally predicted by whether the patient was living with someone prior to their fracture and also by their fracture type. These findings are consistent with the literature. Twelve month accommodation was also predicted by the category of pre-fracture residence, which has been previously reported in the literature, and baseline depression. The EHFS is the first to report an independent predictive effect of depression on accommodation at 12 months post-fracture. This is an important finding as depression is potentially amenable to intervention, though the link between the GDS score and treatable depression is unknown.

Depression in the current study was defined using the short form of the Geriatric Depression Scale. The validity of this scale in measuring depression has not been established and further research is required to do so. It was selected in the current study because it formed part of the RCP and BGS recommendations for assessment of the elderly. In the EHFS depression was analysed as both a binary and a continuous variable. Tables 7.1 and 7.2 both show that more predictors were obtained when the GDS score was analysed as a continuous variable with this being more evident for depression at one month post-fracture. This indicates that information is being lost when the data is simply aggregated and analysed as a binary variable. There was more variability in the distribution of the one month depression scores than there was for the 12 month scores and this is reflected by the greater number of predictor variables obtained for depression at one month when it was analysed as a continuous variable. The EHFS is the first study to report the predictors for depression at one month post-fracture in a hip fracture population. Baseline psychological variables and general health were found to be predictive. Refer to Table 7.1. Additionally walking ability was determined to be an independent predictor when the GDS score was analysed as a continuous variable. General health has been noted to be associated with depression in general populations. One study has been reported in the literature which has performed a multivariate analysis to determine the baseline predictors of depression in hip fracture patients at one year post-fracture. Depression in this study was assessed using the CES-D Scale. The present study confirmed the importance of baseline depression in predicting future depression. It also

established the predictive role of morale, as gauged by the PGCMS, and the strength of religious convictions. The latter variable attained significance only when the GDS score was analysed as a continuous variable. Vision was also found to be predictive in the EHFS and this is another new finding. It was unexpected and may simply reflect the effect of multiple testing. Further research is required to establish its predictive role. The present study failed to confirm a predictive role of ADLs or walking ability for depression at 12 months post-hip fracture.

Predictors for physical dependency at one month post-fracture have not been reported in the literature. In the current study variables indicative of physical frailty prior to the fracture as well as the fracture type were found to be predictive of dependency at this stage for the SRG. Additional variables indicating both mental and physical frailty were found to be predictive for the whole study population at both one and 12 months as shown in Tables 7.1 and 7.2. This was attributable to the greater heterogeneity in the whole study population as well as the larger number of patients in the analysis which increased the statistical power of the analysis to detect significant multivariate relationships. The predictive role of age for both the SR group and the whole study population and accommodation for the latter group only at 12 months found in the EHFS are new findings.

Only one study has looked at the predictors for hip pain at 12 months post-fracture. In that study community-residing individuals were assessed and only baseline depression was determined to be independently predictive. In the present study age, gender, study status, total number of medical conditions, the Barthel mobility subscale score and fracture type were all found to be independently predictive and have not been previously reported in the literature.

The EHFS is the first study to report prognostic factors for hip function using an assessment scale in an unselected series of patients. The Harris Scale was employed to gauge hip function. The baseline variables study status, total number of medical conditions, maximum walking distance and fracture type were found to be predictive.



Considerable overlap with the predictors for hip pain was obtained. This was not surprising as hip pain comprises 44% of the Harris score. The prediction obtained for hip function was reasonable but not good. Part of this may be attributable to the fact that the Harris Scale may not be a very appropriate instrument to use in an elderly hip fracture population as it was designed using young patients with traumatic dislocations of the hip who had no pre-existing impairment in functioning. Also the Harris scale has not undergone any psychometric testing. It was noted in the EHFS that the direction of association for the supported maximum walking distance was opposite for hip pain and hip function indicating that two different dimensions were being assessed which questions the internal reliability of the Harris scale. Indeed few significant correlations were found between the hip pain component of the Harris Scale and the other components.

In summary, where there has been overlap with other studies the EHFS has been broadly similar. However, the EHFS goes beyond the stage of many other studies and there is no comparable information in areas such as hip function.

## **7.5 CLINICAL APPLICATION**

The current study provides normative data on outcome in an unselected series of hip fracture patients using a series of standardised assessment scales. These scales encompass the recommendations from the joint working party of the Royal College of Physicians and the British Geriatrics Society in 1992 and 'will form the basis of a common clinical language' as their use becomes increasingly widespread. It is therefore useful to have the characteristics of hip fracture patients documented in this way.

The present study has also documented a fuller range of outcomes in both the shorter and longer term than the other hip fracture studies. Hip pain and function in particular have been more extensively recorded. As a result, a more comprehensive picture of outcome in hip fracture patients is therefore now available to the physician than was previously available, and this should facilitate clinical management.

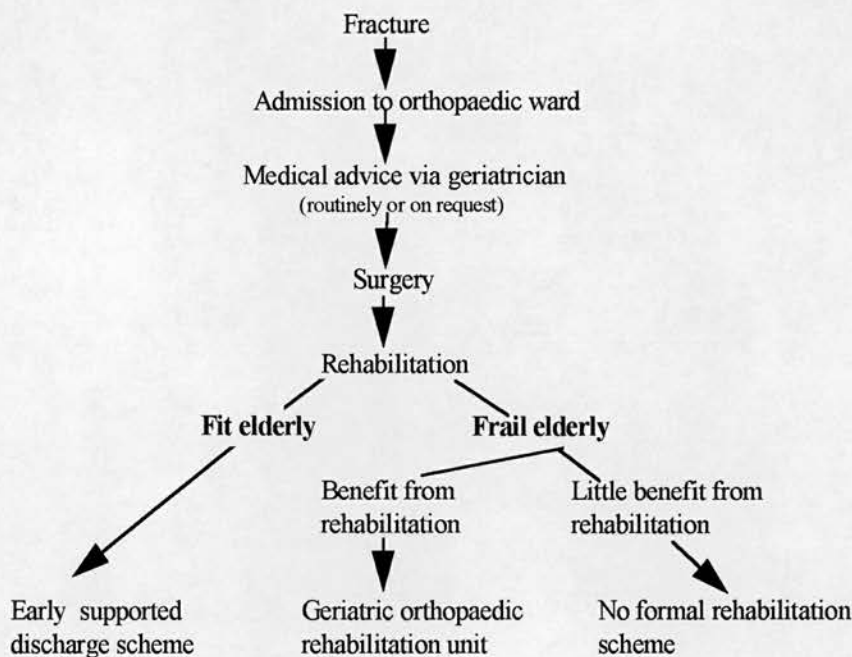


One finding that was of particular note in the current study was that 12%, or 23 patients, had shortening of one inch or more of their fractured femur one year after their fracture. Not all of these patients had been detected on routine orthopaedic follow-up or by their general practitioners on any consultations that they may have had with them over the year following their fracture. It is an important complication to detect as a shoe raise will improve the walking ability of these patients and hence the quality of their lives. Consequently clinicians, as well as patients, or their carers where this is applicable, need to be made more aware of this possible complication so that it may be identified at an early stage. No obvious factors predicted or were associated with shortening. Even among patients reporting limp only 18% had shortening greater than one inch. This data coupled with a consideration of the criteria for effective screening (Wilson and Junger 1968) suggest that screening for femoral shortening following hip fracture should be undertaken in all hip fracture patients. The exact timing of the screening is somewhat arbitrary, but the EHFS data suggests that this should be done no later than six months post-fracture.

The EHFS also documented the high prevalence of pain in the region of the hip following fracture. This finding should stimulate clinicians to enquire about this complication and to establish whether there is a potentially reversible underlying cause, such as limb shortening, and instigate the appropriate management. If no reversible cause is found then the clinician should ensure that appropriate analgesia is prescribed.

The clinical management of hip fracture patients could be enhanced by the use of prognostic indices. Firstly, the systematic assessment of patients that would be required to provide the necessary information for the indices would have the benefit of encouraging a more comprehensive and focused assessment of the patients and thereby improving their clinical care. Secondly, the assessment of the prognosis of individual patients may be more objective if indices are used than if clinical judgement is employed in isolation and this would inform management planning (Thorngren et al 1990).

It is in the area of rehabilitation that prognosis-based decision making may be of greatest benefit as far as the clinical management of hip fracture patients is concerned. A triaging system for rehabilitation of hip fracture patients could be established using the different types of rehabilitation schemes outlined in chapter 1. Refer to Figure 7.1 for a diagrammatic representation.



**Figure 7.1** Management of hip fracture patients (Adapted from RCP (1991))

The use of prognostic indices, in conjunction with clinical expertise, could help select the most appropriate rehabilitation scheme for individual patients. This would be most helpful if it could be realised within a few days of the patient’s admission so that discharge planning could begin at an early stage (Ensberg et al 1993). In the EHFS a specific outcome variable to reflect suitability for the different rehabilitation schemes was not identified at the planning stage of the study. This was because at the time the EHFS was being carried out the discharge arrangements for patients were being modified to incorporate early supported discharge. One possible outcome variable that might have been employed for this purpose is ‘discharge to non-institutional accommodation within 10 days of the definitive surgical management of the hip fracture’. For illustrative purposes, the outcome variable one month accommodation will be used to show the potential of prognosis-based rehabilitation. Although not directly assessing the proposed

variable, the rank ordering of scales for this prognostic index could be used in assessing the suitability of patients for ESD. The range of index values generated by the EHFS cohort of patients for one month accommodation could be categorised to reflect 'good', 'intermediate' and 'poor' rehabilitation potential. The group of patients with the 'good' scores are likely to be the mentally and physically fit hip fracture patients whose fracture represents a simple accident. The remaining patients would be the frail elderly whose hip fracture represents part of their physical, mental and social decline. The patients with the 'intermediate' scores would benefit from rehabilitation whilst those with 'poor' scores would benefit very little. The patients in the 'good' group would be eligible for the Early Supported Discharge Schemes. Patients in the 'intermediate' group would be eligible for the Geriatric Orthopaedic Rehabilitation Units (GORU). The group of patients who would not gain any benefit from rehabilitation would be largely comprised of individuals with severe dementia. If in institutional care, they could be discharged back there shortly after the definitive management of their hip fracture. Such an approach would allow clinical resources to be channelled into the middle band of patients for whom additional rehabilitation support would be of most benefit. It is also important to identify those patients for whom ESD is appropriate because of the benefits that have been identified from this rehabilitation approach, in terms of a quicker rate of physical functioning (Pryor et al 1988, Pryor and Williams 1989, Parker et al 1991, Cameron et al 1993) and patient satisfaction (Currie 1994) as well as a lower rate of long term institutionalisation (Holmberg et al 1989, Cameron et al 1993).

Clinically two other outcomes in the EHFS are amenable to change, namely depression and hip pain. Depression is an important health condition to identify in terms of well-being of the patient, and it may also interfere with their rehabilitation post-fracture. Using prognostic information a high risk group of patients could be identified and these patients could be monitored closely by the patient's general practitioner, or the rehabilitation team, for the development of signs and symptoms indicative of clinical depression. However, before this approach could be recommended, further work has to be undertaken to establish the usefulness of the short form of the Geriatric Depression Scale in classifying depression.

Hip pain is a very important outcome from the patient's viewpoint. However the prognostic index was relatively poor at predicting this complication. Given the high prevalence of hip pain, a more general awareness of this complication should be fostered among clinicians and the various causes of pain in the region of the hip should be assessed and treated, for example, by prescribing analgesia as required to keep the patient comfortable.

The prognostic indices derived in the EHFS for single dimensions of outcome need further modification and development before they are adopted for clinical use. However, they have within the thesis, demonstrated their potential, particularly in relation to triaging for rehabilitation.

An overall assessment of outcome may however be of more use in a clinical setting than individual outcome measures to give an indication of 'severity', and may also be more acceptable to clinicians. The derivation of such an index would require a consensus of opinion involving orthopaedic surgeons, rehabilitation and geriatric medicine specialists, public health physicians and patients. The index would have to have high face validity for it to be adopted into clinical practice and the predictor variables in the model would also have to be readily available or not too onerous to collect. Staff may have to be trained in the use of standardised assessment scales for example, and appropriate forms and databases would have to be in place to ensure that the data were adequately captured in a systematic way which was readily retrievable. Other difficulties that may be encountered in the clinical setting is that collecting the data required for a prognostic index would increase the workload of the clinical staff. Given their already heavy workload, clinical staff may make data collection a low priority compared to their other obligations. Some people may also view standardised assessments as being a threat to their clinical autonomy and not be very willing to use them. However the rising profile of clinical audit in the National Health Service will give impetus to the changes required at a clinical level for the successful introduction of prognostic indices.

The actual implementation of a prognosis-based approach to clinical management depends on clinicians being convinced of its value, and hence dissemination of information is required. Findings need in some sense to be 'marketed' to clinicians. The uptake of the Glasgow Coma Scale (Teasdale and Jennett 1974) and the CRIB index (International Neonatal Network 1993) does demonstrate that prognosis-based management will be adopted by clinicians under the right circumstances.

## **7.6 PUBLIC HEALTH IMPLICATIONS**

The relevance of the results of the EHFS to Public Health may be categorised into three main areas. The first of these is the provision of descriptive epidemiological data on the baseline and secular characteristics of hip fracture patients which enables their disability and health needs to be quantified. The second is to provide prognostic information on hip fracture patients which may enable the most appropriate management of patients to be undertaken to maximise health gain within a constrained budget. The area of management which lends itself most readily to this approach is rehabilitation and this has already been discussed in section 7.5. The third area is in the increasingly important area of audit. Prognostic indices may prove to be invaluable by permitting a more meaningful comparison between centres by adjusting for casemix. In addition we have identified shortening and long term hip pain as important outcome measures for surgical audit. The relevance of each of these three areas to Public Health will now be expanded upon.

One of the central roles of Public Health Medicine is to establish health needs at a population level. Fundamental to this is the requirement for good epidemiological data on health and disease. Only limited data on this is available from routine sources. Studies such as the EHFS provide much needed information for health needs assessments. The EHFS has made an important contribution to Public Health by furnishing very detailed epidemiological information, using standardised scales, on an important client group which uses considerable resources. The EHFS clearly showed the high dependence of hip fracture patients on the health and social services at the time of their fracture. It documented the greater dependence of hip fracture patients to one year post-fracture and



their greater utilisation of the health and social services. Interestingly, it found that although the surviving patients were more dependent their dependence on the health and social services was offset to a greater degree by the frailer individuals at the outset of the study dying during the course of follow-up. The number of patients who required home helps decreased from 77 to 52 over the 12 follow-up month period and the number of patients in supported forms of care also declined. This was an unexpected finding and should help with the planning of service requirements of hip fracture patients.

From a health planning point of view it should be noted that at present the links between scale scores and resource use is unknown. Results from studies such as the present one should facilitate development of knowledge in this area and this may be of considerable use to Public Health Medicine. Also if the scales recommended by the joint working party are widely adopted then comparative information would be available for different patient groups, and resource allocation may be more effectively distributed to meet patient need.

Public Health Medicine also has an important role in ensuring that the most effective use of health service resources are made to maximise health gain in populations. Since hip fracture patients are major users of resources, and the number of hip fracture patients is set to escalate, as described in section 1.2.5, it is becoming increasingly important to identify ways in which the burden from hip fracture patients can be made more efficient without compromising their health. As outlined in section 7.5, increasing the efficiency of rehabilitative management offers the most potential at present to do this, as prevention of hip fractures and improvement in current surgical management both appear to have limited scope. Using a prognosis-based approach to triaging will allow resources to be concentrated in the group for whom rehabilitation would make the most difference. Although further work is required on the EHFS data to derive indices that would be suitable for triaging for rehabilitation, it does indicate the potential of this approach. The ability to identify those patients for whom the ESDS would be appropriate using indices predicting rehabilitation potential would result in substantial savings, whilst simultaneously enhancing patient outcome. These savings could be used to help manage the rising number of hip fracture patients. The Public Health Physician therefore has a role to ensure

that appropriate prognosis-based rehabilitation strategies are in place when contracting for hip fracture services. The contracting process would also require Public Health input to ensure that appropriate quality control mechanisms are in place, such as monitoring of hospital re-admission rates for patients who participate in ESDS.

The third main area in which the results from the EHFS could be of benefit to Public Health Medicine is in the audit of hip fracture patients. Prognostic indices may be of benefit in audit by permitting adjustment for casemix. This would mean that outcome data could be assessed more meaningfully in patient populations, and this could be at a hospital level or health board level for example. Without such adjustment, comparisons of outcomes for patients cared for at different facilities, or other patient group comparisons, may be misleading. To illustrate the application of prognostic indices in audit, the index for one month mortality will be given, as this was one of the two outcome measures identified by CRAG for audit purposes.

For each patient that was admitted to hospital for the definitive management of their hip fracture the probability of the patient surviving to one month post-fracture could be calculated using the approach outlined in section 5.2.3. The baseline characteristics of the patient would be entered into the prognostic index and a value for the index,  $y$ , obtained. The probability of death could then be determined using the formula  $p(\text{death}) = 1/(1 + e^y)$ . This could be done for all the patients in the defined population and the probabilities for the survival of each patient summed to give the expected number of deaths that would occur by one month post-fracture. The observed number of deaths in this population at one month post-fracture could then be obtained from the Registrar General's Office. The observed number of deaths could then be compared with the expected number of deaths calculated from the prognostic index and this would give an indication of relative performance. The same exercise could be repeated in different hospitals or health boards in Scotland and their relative performances could be compared.

The thesis demonstrates the degree to which various aspects of outcome can be predicted. In a sense it gives a benchmark for what might be achieved by casemix adjustment in clinical audit which is very useful from a Public Health point of view. The variables as recorded in the EHFS are not however routinely collected which essentially leads to two options. Firstly, indices could be derived which only use data which is collected routinely. The problem with this is that only a very limited range of data is collected routinely and casemix adjustment would be less effective than suggested in this thesis. Of the variables that are recorded routinely, age, accommodation type, and fracture type are predictive of most outcomes whilst the sex of the patient was found to be irrelevant to outcome. At the present point of time the issue of what can specifically be done with routine data has not been investigated as research has been directed at looking to see what can be done from optimal recording. The second option is to record additional variables. The major difficulty here is the establishment of routine record systems to capture data on all patients. It also has to be borne in mind that for audit, outcome measures have to be obtained as well as casemix indicators. The potential extra costs in terms of resources is very much dependent on the choice of predictors and outcome variables selected for audit. The joint working party's recommendations of a minimum data set for audit purposes are probably not feasible in practice. Data collection for the scales takes around one hour and the committee's recommendation in this respect must be queried.

Effective casemix indicators are therefore unlikely to be achieved without additional data collection. Extra work is required to establish the minimum data set which can be used to predict outcome successfully. This points to the benefit of having an overall index to minimise the additional data collection.

The results from the EHFS clearly have implications for the collection of routine health service data as described above. Additionally, the study identified two areas of unmet need, namely hip pain and femoral shortening. It is proposed that it would be good clinical practice to record hip pain and leg length routinely during follow-up.

For audit purposes the proportion of patients for which these data are recorded could be assessed.

## **7.7 FURTHER DEVELOPMENTS**

One of the problems with thesis work is that it is meant to reflect three years of research effort. As a result, this thesis represents only part of the Edinburgh Hip Fracture Study. Consequently the thesis limited itself to addressing aims one and two of the EHFS, namely presenting the descriptive epidemiology of the hip fracture population and deriving prognostic indices for various dimensions of outcome.

Ongoing work has involved a validation study being undertaken to test the indices derived in the EHFS on an independent cohort of patients. It was decided to validate the indices for different dimensions of outcome at one month post-fracture, and at six months post-fracture as there had been little change in the cohort between six and 12 month post-fracture. The decision to validate the indices for outcome at six months required much additional work as a new set of predictors for outcome at six months had to be derived for the EHFS. Additionally, the existing indices were too complicated to be used in a clinical setting or for audit purposes. Consequently simplified indices are being employed thereby fulfilling aim three of the EHFS. Reduced sets of questions replaced the scales in the prognostic indices by employing further multivariate techniques. Further simplification by rounding the regression coefficients was also used making the indices easier to calculate in practice. Early results confirm the overoptimistic assessment of prediction which results from unvalidated prognostic indices. It is outwith the scope of this thesis to present the detailed results of the validation study and the simplified indices. However, the main findings are that the indices were found to be reasonably robust for prediction of accommodation, dependency, depression and hip function.

Derivation of prognostic indices to date have been obtained separately for each dimension of outcome. For audit purposes, an overall index might be more useful. An index of 'severity' which covers the likelihood of dying, being dependent, or being institutionalised for example would potentially be of great benefit to clinicians and for audit purposes. This



could be approached using methods of canonical correlation. Such an index will permit adjustment for casemix and its derivation would address aim four of the EHFS. This work remains a goal for future development and will fulfil aim four of the EHFS.

The prognostic indices presented in this thesis are based on the pre-fracture status of the patient and are not modified by details of the patient's acute hospitalisation experience. Further statistical effort will have to be expended to incorporate these details. It may be argued however that planning for rehabilitation should be commenced at the time of the patient's admission which would obviate the need for incorporation of their acute hospital details. However, the inclusion of acute hospital variables into the prognostic indices would add the 'process' dimension of the health care of hip fracture patients, and this may provide useful data for audit purposes, though it could not be used legitimately for casemix adjustment.

Despite the importance of hip fracture there is a paucity of information on which long term resource planning can be based. No research had documented the outcome of an unselected cohort of patients at a uniform time point in a comprehensive manner prior to the EHFS. The cohort of patients assembled for the EHFS in 1991/92 provided a unique opportunity for supplying such information and a five year follow-up study has now secured funding.

The implications of the EHFS for future research include the need to improve the indices by concentrating on simplicity and using data which is available routinely. The indices also need to be evaluated on other hip fracture populations, and a multi-centre evaluation needs to be conducted. Centres with different rehabilitation policies need to be included in the evaluation process to ensure generalisability.

## **7.8 SUMMARY**

The EHFS has made an important contribution to the state of knowledge about outcome following a hip fracture in an unselected series of patients using a methodologically sound study design. At the most basic level, it provides population based data on the outcome of



hip fracture patients over a one year period in the setting of a teaching hospital. This is of potential use in the planning of the health and social service provision for such patients. Surprisingly the study showed that at one year post-fracture the overall burden to the health and social services by the study cohort had declined compared to their pre-fracture requirements. This arose because the increased morbidity of the survivors was offset to a larger degree by the death of the frailer individuals at the outset of the study. At a more sophisticated level, prognostic indices have been derived for a broad range of outcome variables: namely mortality, accommodation, depression, dependency, hip function and hip pain. Of these indices one month accommodation and dependency may be the most useful because of their potential role in facilitating the identification of the most appropriate rehabilitation scheme for hip fracture patients in conjunction with clinical judgement. Increasing the efficiency of management is currently thought to be the most effective way of reducing the burden imposed by the ever increasing number of patients with hip fractures. The prognostic indices, by adjusting for casemix, may also prove to be of use in clinical audit which is gaining momentum with the current changes in the NHS. Further work is still required to develop and exploit fully the results of the EHFS. Prognostic indices for different dimensions of outcome need to be simplified further and an overall index for clinical management and audit purposes needs to be derived to indicate the 'severity' of a hip fracture patient. These indices also need to be evaluated in other centres. The EHFS has to date nonetheless managed to give an indication of the feasibility of the indices for triaging and casemix adjustment, and has generated indices which could be used now, although they would be a little cumbersome and require additional data collection. The EHFS has also identified two areas of unmet need, namely hip pain and femoral shortening, and these two outcome measures could be used as assessment tools in surgical audit. In producing data on a wide range of outcome variables for what is one of the largest unselected series of osteoporotic hip fracture patients, and documenting their progress to one year, it has established a base from which further developments in the management of hip fracture patients can expect to flow.

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